The Montana Science and Technology Policy and Plan

Montana Science and Technology Advisory Council

JUNE
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Montana Science & Technology Alliance

Department of Commerce
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406-449-2778

FRONT COVER PHOTO:
Close-up of an unmachined metallic silicon crystal grown by Lattice Materials Corporation of Bozeman. The finished crystals are used in infrared laser and imaging systems.

Montana Science and Technology Alliance

Montana Science and Technology Advisory Council

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OFFICE OF THE GOVERNOR OF THE STATE OF MONTANA

June 17, 1991

My fellow Montanans,

This Montana Science and Technology Policy and Plan belongs to all of us.

The Plan outlines a number of actions, not that we *should* take, but that we *will* take to prepare ourselves and our State for the twenty-first century. The policy provides a guide for those actions. The Plan builds on Montana's existing resources–human, institutional and material–and provides opportunity for individual initiative.

I am adopting the Plan as it concerns my responsibilities as your Governor. Join me in making its vision a reality by taking the opportunities it presents you.

Sincerely,

STAN STEPHENS
Governor

Letter of Transmittal

June 17, 1991

The Honorable Stan Stephens
Governor of Montana
State Capitol Building
Helena, Montana 59620

Dear Governor Stephens:

It is our pleasure to provide you, in response to Executive Order 13-90, the Montana Science and Technology Policy and Plan. The Policy and Plan were developed by the Montana Science and Technology Advisory Council and represent the unanimous consensus of its membership. It was reviewed by the Montana Board of Science and Technology Development, whose observations are incorporated in the document.

The plan and its background analysis incorporate information gleaned from a wide range of reports and analyses concerning Montana and its place in today's national and international economies. It also reflects, in addition to those of the advisory council members, the opinions and suggestions of a variety of Montanans gathered through extensive interviews and three public hearings.

We would like to stress that this document is a plan for action, not a report. It outlines processes through which Montanans, working together, can prepare themselves and their State for the twenty-first century. Responsible parties have indicated their willingness to undertake the various action items, most of which can be undertaken within existing resources and organizations. In some cases, in fact, the action items make resources of what have previously been perceived as drawbacks.

There are some new exciting challenges as well as fresh perspectives on many familiar opportunities addressed in the plan and background analysis. We trust that you, Governor, will find this action plan a useful tool towards accomplishing your goals and responsibilities.

Sincerely,

Robert E. Ivy
Chairman
Montana Science and Technology Advisory Council

Ray V. Tilman
Chairman
Montana Board of Science and Technology Development

WILLIAM R. SALLAZ

Forestry seedling facility of Champion International Corporation.

Forestry and wood products focus group established under the plan will help ensure the economic viability of this industry in Montana.

Table of Contents

Policy

The State of Montana is committed to the development and application of science for the betterment of the people of Montana. By fostering cooperation among government, universities, and the private sector, the State can utilize existing and potential strengths to expand expertise in science and technology. The ultimate purpose of this Policy is to maximize our opportunities to develop jobs, add value to existing resources, increase our educational opportunities, expand entrepreneurship, improve the scientific infrastructure, and encourage discovery.

Laboratory research facility at Montana State University.

The ultimate purpose of the plan is, in part, to improve the scientific infrastructure and encourage discovery.

American Indian high school student participates in a summer research program at Montana State University.

Efforts such as the American Indian Research Opportunities program, a consortium of the seven Tribal Colleges and MSU, improve the quality and sharing of resources for and among the Tribal Colleges and MSU to develop a critical mass of talent in science and technology fields that relate to the needs of industry.

Executive Summary

Montana is part of what has been called the "new technological economy." Its major features are continuing advances in information processes and materials, leading to descriptions of this era as the "information society" or as the "materials economy." In practical, day-to-day terms, this new economy involves new processes, changes of scale, and greater room for personal initiative. It is markedly different from the centralized, mass-production industrial economy of the last 100 years. This report shows some of the ways in which Montana can build the material, human, and institutional resources to participate and succeed in the new technological economy. The challenge is to mobilize these resources in relation to the new economy.

The industries that exploit the State's wealth of material resources—agriculture, mining, forestry—are primarily extractive, with relatively little value added. Worldwide, the initial processing of raw materials is moving closer to the point of extraction, but little of this has happened in Montana. The challenge is to develop a new way of looking at Montana's economy and to develop the technologies and industries that will move the State further along the "value-added spectrum."

Montana's human resources include a generally well-educated workforce and a significant number of entrepreneurs. However, too many of its best students leave the State, while technological entrepreneurship is constrained by shortages of capital, technical support, and skilled workers in key areas. Intellectual capital—workforce "know-how"—is the most critical resource in the new technological economy, and its development is a key dimension of this Plan.

Montana has in place much of the necessary institutional framework for education, research, and development. However, these organizations are not mature or well networked. Furthermore, the existing resources are not always accessible or utilized. Networking is necessary if the continuing information explosion is to be put to work for Montana's benefit. The principal challenge is to improve the coordination of the efforts of existing organizations.

Underlying the new technological economy is the need to create a climate in which science and technology research can be fostered and expanded. The challenge is to direct State resources to attract third-party resources that will be used to develop research expertise in identified areas important to the State.

Analysis has identified specific opportunities that are presently available and can be developed as components or actions items in this Montana Science and Technology Plan:

1. Strengthen and extend existing research capabilities.

2. Recruit people who produce industries; don't "chase smokestacks."

3. Pursue appropriate high-profile scientific projects.

4. Prepare the public to participate in the new technological economy.

5. Convene statewide "focus groups" to set the agenda for cooperation among sectors, including the development of research agendas.

6. Establish networks to allow Montanans to access resources such as scientific expertise, technology, and related financial and management assistance.

7. Improve and expand the existing telecommunications infrastructure as necessary.

8. Develop a Montana high tech business council to strengthen cooperation and growth and to provide a forum for common concerns.

9. Legitimize and facilitate cooperation between industry and Montana universities.

10. Encourage and coordinate technology development, transfer, and implementation.

11. Develop third-party revenue streams to assist the financing of the Montana Science and Technology Plan.

12. Provide an organization, authorized by the Governor, to police and encourage the Policy and approved actions defined by the Science and Technology Plan.

Vital to all of the above opportunities is the need for extensive, widespread communication, as well as a forward-looking, national and international perspective. These needs must be addressed, not through quick fixes or ad hoc course corrections, but through new or modified processes that enable Montanans to communicate across institutional and geographic limits on a continuing basis. This Plan provides for the development of these processes in ways that are formally recognized, and yet open to broad participation and individual initiative. By taking that initiative and acting on this Plan, Montanans can strike out with confidence to prepare themselves and their State for the twenty-first century.

Alpine Log Homes exploits an under-utilized resource, standing dead timber, in its construction.

The challenge is to develop a new way of looking at Montana's economy and the technologies and industries that will move the State further along the "value-added spectrum."

The Science and Technology Plan

Knowledge is the greatest economic resource of the future, and science (knowing about things) and technology (knowing how to do things) are the most significant forms of knowledge. They deserve as much attention as is provided for the financial resources that are derived from their use. Under this Plan, Montana will give them that attention.

Just as the Policy at the start of this document is a *guide* to action, this Plan is a *blueprint* for action. It outlines six sets of activities that not only should be, or need to be taken, but will be taken over the next months and years. *The activities it encompasses will set Montana and Montanans squarely in the economic mainstream for the foreseeable future, if they are effectively implemented.*

That assertion can be made so boldly, not because Montana's Science and Technology Advisory Council, its staff, and its consultants have detailed answers, but because this Plan spells out a set of processes through which Montana's leaders can face and cope with the challenges that now exist and will arise in the next few years. These processes are designed to help make certain that most Montanans understand the new economic realities; that they understand how Montana's exceptional resources relate to those realities; that they are organized in ways that allow them to use their resources effectively and to develop the new skills and tools and knowledge they will need; and that they can do so efficiently within the context of highly competitive international markets.

The first task is to see to it that Montanans understand as well as possible the new technological economy and the opportunities it offers to this State and its people. Table 1-I presents the detailed actions for achieving this goal. The Steering Committee that will oversee this public education and awareness program will be broadly representative of Montana's educational, political, business, scientific, and technological leadership. Two Task Forces, one using mass media and one using speakers and symposia, will develop specific materials and programs designed to help the population at large understand what is happening in the worlds of knowledge and of work. More importantly, they will be designed to help Montanans understand how they can capitalize on change as it occurs into the twenty-first century, in order to improve their economic condition and their quality of life.

While this educational program is being developed, leaders in the key sectors of Montana's economy will be meeting in seven Focus Groups to define measures needed to strengthen each of these sectors over the next decade and into the twenty-first century (see Table 1-II). Each of these groups will look at how its industry is being shaped by national and international forces, and how it is being or can be changed through science and technology. They will be developing consensus among Montana's universities, industries, political leaders, and other affected groups as to research and development needs, educational requirements, public policies toward business and education, and other concerns that are relevant to their respective fields. These agreements are expected to shape university research and education agendas, elicit industry support for education and research, and guide public policy considerations in the years ahead. In doing so, they will help to ensure the economic viability of Montana industry and healthy economic opportunities for Montana's citizens. These seven Focus Groups will address the following fields: (1) mineral extraction and processing, (2) forestry and wood products, (3) agriculture (with subgroups in livestock and crops), (4) energy resources, (5) biotechnology and its applications, (6) communications and manufacturing processes and technology, and (7) basic research capacity.

Parallel to the above activities, a special campaign will be taking shape to raise needed private funds, especially from outside Montana's borders (Table 1-III). Initial estimates indicate a capital deficit of over $250 million for science and technology activities throughout the Montana university system. This includes buildings, equipment, and endowment for existing and additional faculty chairs. These deficits affect nearly every program at each of the six schools, from training math and science teachers as well as practicing scientists and engineers, to conducting research that is qualitatively excellent and relevant to the future of Montana. Montana's taxpayers already support their universities to an extent similar to several neighboring States. However, Montana's public universities have never undertaken major drives for support from national and international industries and foundations on the scale employed by public universi-

ties in other States. Stable and continuing State commitments by way of money to initiate the effort and modest matching funds to augment it will be required. This campaign will close the basic gap.

Much has been said in recent years about building educational "pipelines," from kindergarten into adult employment *in Montana*, for far more of Montana's young people. Existing fragmented efforts will be pulled together through the fourth element of the Plan, as shown in Table 1-IV. Major attention will be devoted to helping parents communicate more effectively with their children on science and technology matters; to improving teacher preparation and in-service teacher education; to equipping the universities to match the facilities available in many Montana high schools; and to making Vo-Tech more directly and quickly responsive to rapidly emerging industry and worker needs for skills not covered by conventional programs. And a program plan will be developed to assure statewide availability of off-campus, in-service professional and technical education.

Cutting down on the time and effort needed to get know-how out of the universities and put it to work in business and industry will highlight the next element of the Plan (Table 1-V). Consistent policies will be developed with regard to university patents and copyrights as well as industry access to university facilities and equipment. A fair and consistent set of rewards will also be developed for faculty involvement with industry. Perhaps most significantly, the three technological universities will employ "technology discovery and applications experts," and their interface with industry will be expedited and coordinated by the Commissioner of Higher Education, in cooperation with the Montana Science and Technology Alliance. This proactive team will help to put the wealth of knowledge in the universities to work. This team will develop close working relationships with existing programs such as the Montana Entrepreneurship Center, the University Technology Applications Program, Northern Montana's industrial modernization assistance activities, and the Cooperative Extension Service.

Finally, the development and control of science and technology policy in and for the State will be institutionalized in the strongest possible setting—in the Executive Office of the Governor (Table 1-VI). The Montana Science and Technology Advisory Council, in conjunction with the Montana Science and Technology Alliance, will become the continuing arm of the State government for this purpose. It will oversee the implementation of this Plan, with staff support from MSTA, and will be responsible for updating or revising the Plan every two years. Knowledge is the greatest economic resource of the future, and science (knowing about things) and technology (knowing how to do things) are the most significant forms of knowledge. They deserve as much attention as is provided for the financial resources that are derived from their use. Under this Plan, Montana will give them that attention.

The six key elements of this Plan, which are detailed in Table 1 and summarized in Figure 1, have been developed by the Montana Science and Technology Advisory Council, drawing on the Background Analysis that follows. Figure 2 relates the initial efforts under the Plan to the mid- and long-term development of Montana. Appendix A presents a bibliography of materials relevant to the Plan and Background Analysis. Appendix B is Executive Order 13-90, which established the Montana Science and Technology Advisory Council.

Remote electronic animal data system (READS) developed and commercialized by GeoResearch, Inc.

The plan's agriculture focus group will work toward developing healthy economic opportunities for Montana's citizens in the agricultural industry.

TABLE 1

ELEMENTS TO THE MONTANA SCIENCE AND TECHNOLOGY PLAN

	ACTIVITY AREAS	KEY ACTIONS	RESPONSIBLE PARTIES	WHEN
I.	Public Education and Awareness —Sell the Model	A. Establish Steering Committee.	Governor or Designee—to include educational and business leaders and practicing scientists and engineers	By September 1, 1991
		B. Establish Task Forces for Production and Implementation of Programs through: 1. Mass Media, building on such university programs as Montana Tech's "Society and Technology" and Montana State's Science Outreach 2. Conferences/Speakers, building on such efforts as the "Which Way to Tomorrow?" forums in the upper Flathead Valley.	Steering Committee— 1. Mass media task force to include representatives of television and radio broadcasting, cable TV, and the universities and public schools. 2. Conferences/Speakers Task Force to include all universities, community colleges, and Vo-techs, the Office of Public Instruction, statewide educational associations, the Montana Ambassadors, Montana Industries Association, labor, Chambers of Commerce, civic clubs, and the Cooperative Extension Service.	By October 15, 1991
		C. Program Development and Production	Task Forces	Jan. – Aug. 1992
		D. Program Implementation	Task Forces	September 1992 and continuing
II.	Convene Focus Groups in 1. Mineral Extraction and Processing 2. Forestry and Wood Products 3. Agriculture, with subgroups for a. Plants b. Animals 4. Energy Resources 5. Biotechnology and its Applications 6. Communications and Manufacturing Processes and Technology 7. Basic Research Capability	A. Establish First Set of Seven.	Governor, on advice of Montana Science and Technology Advisory Council, with Membership as inclusive as possible	Sept. 1, 1991
		B. Focus Groups Meet, Develop Action Plans that: 1. Identify Montana's needs and interests 2. Examine issues related to efficiency, value-added opportunities, reutilization of existing wastes, and alternative uses for the industry's raw materials and products 3. Identify relevant in-State research and applications capabilities and needs, such as laboratories and centers of excellence 4. Identify external support resources.	Group Participants, Coordinated by MSTA	Oct. 15, 1991 to Oct. 15, 1992
		C. Feed Relevant Findings to Other Focus Groups.	Each Focus Group	As Identified
		D. Focus Groups Submit Action Plans, with Budgets.	Group Participants, Coordinated by MSTA	June 15, 1992
		E. Consolidation of Plans and Requirements	Montana Science and Technology Advisory Council	Sept. 1, 1992
		F. Implementation of Plans	As determined in the process of developing the plans	Continuing
III.	$250 Million Fundraising Drive to Develop a Sound Science and Technology Base for Montana—Inside and Outside Montana	A. Hire Professional Fundraiser, via RFP and Negotiation.	Montana Science and Technology Advisory Council, with support from MSTA and in coordination with the State Board of Regents and the Commissioner of Higher Education	Dec. 1991
		B. Develop the Details of the Program, incorporating information from Focus Groups.	Fundraiser, in coordination with the Focus Groups, MSTA, and the University system	January to June 1992
		C. Compile and Confirm Dollar Requirements.	—same—	June to September, 1992
		D. Raise the Funds.	Fundraiser, with support of all State entities	December 1992 to December 1997

ACTIVITY AREAS	KEY ACTIONS	RESPONSIBLE PARTIES	WHEN
IV. Human Resource Development and Preparation, including: 1. Parental education 2. Networking for student access to remote resources 3. Teacher preparation 4. In-Service teacher education 5. Curriculum enrichment and supplementation 6. Equal opportunity (race- and gender-neutral instruction) 7. Vo-tech ability to provide quick response to industry 8. Higher education relevance to real opportunities in Montana 9. Statewide in-service education, off-campus, for professional and technical workers	A. Delegate or Assign for Action to responsible educators identified strengths and weaknesses in "K-12" and "K-100," building on existing resources and officials wherever possible.	Montana Science and Technology Advisory Council and Focus Groups	As the strengths and weaknesses are identified and confirmed during the Focus Group process.
V. Improve Transfer of University Technology and Expertise to the Public	A. Develop Consistent Policies among all universities, addressing both: 1. Intellectual property, and 2. Use of university facilities and equipment.	Commisioner of Higher Education, in coordination with MSTA and MSTAC	By January 1, 1992
	B. Develop Rewards to Faculty for service to business and industry, and for patents and copyrights.	Commisioner of Higher Education, in coordination with MSTA and MSTAC	By October, 1992
	C. Establish a Montana Technology Discovery Network, with representatives at Montana State, University of Montana, and Montana Tech, drawing on the Offices of Research and Technology Applications of in-State and nearby Federal laboratories, and coordinated by the Commission on Higher Education in coordination with the Montana Science and Technology Alliance.	Commisioner of Higher Education, in coordination with MSTA, MSTAC, MSTDB, and the Montana Department of Commerce	By October, 1992
VI. Institutionalize Science and Technology Policy and Control	A. Establish the Montana Science and Technology Advisory Council as the continuing policy development arm of the State, within the Executive Office of the Governor, to carry out activities defined in this Plan.	1. Governor, with MSTAC 2. Legislature	January, 1992 1993
	B. Transfer MSTA Staff to Governor's Office, as staff to both MSTAC and MST Development Board.	Governor	January, 1992
	C. Produce or Update the Montana Science and Technology Policy and Plan	Montana Science and Technology Advisory Council	Biennially, with next revision in May 1993

HIGHLIGHT

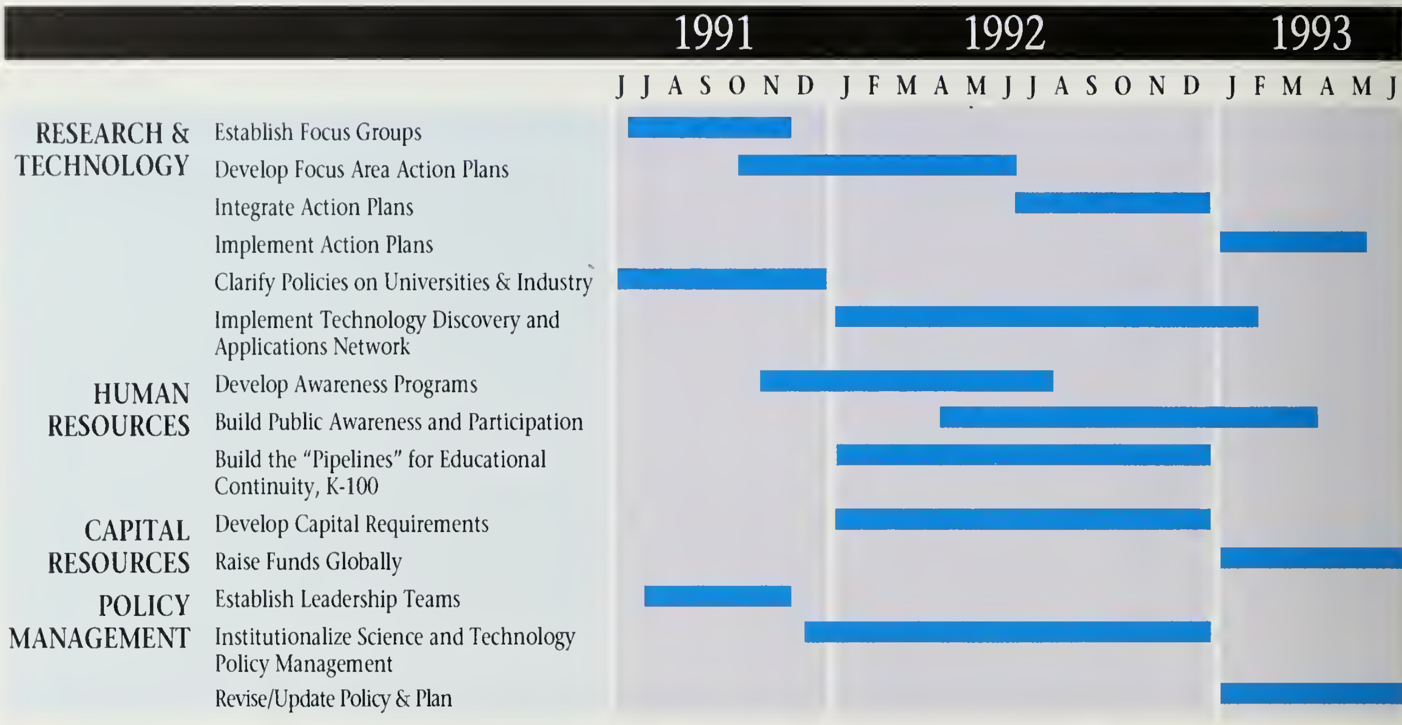
In a March 27, 1991, letter to Governor Stephens, the new Director of the National Science Foundation, Dr. Walter E. Massey, reviewed the initiatives that NSF is taking in Fiscal Year 1992 to address State concerns nationwide. These are:

- Materials synthesis and processing;
- Academic research instrumentation;
- Precollege science and mathematics programs;
- Undergraduate science, mathematics, and engineering programs;
- Statewide systemic initiatives;
- State/Industry/University cooperative research centers
- Science and technology centers; and
- Experimental Program to Stimulate Competitive Research (EPSCOR).

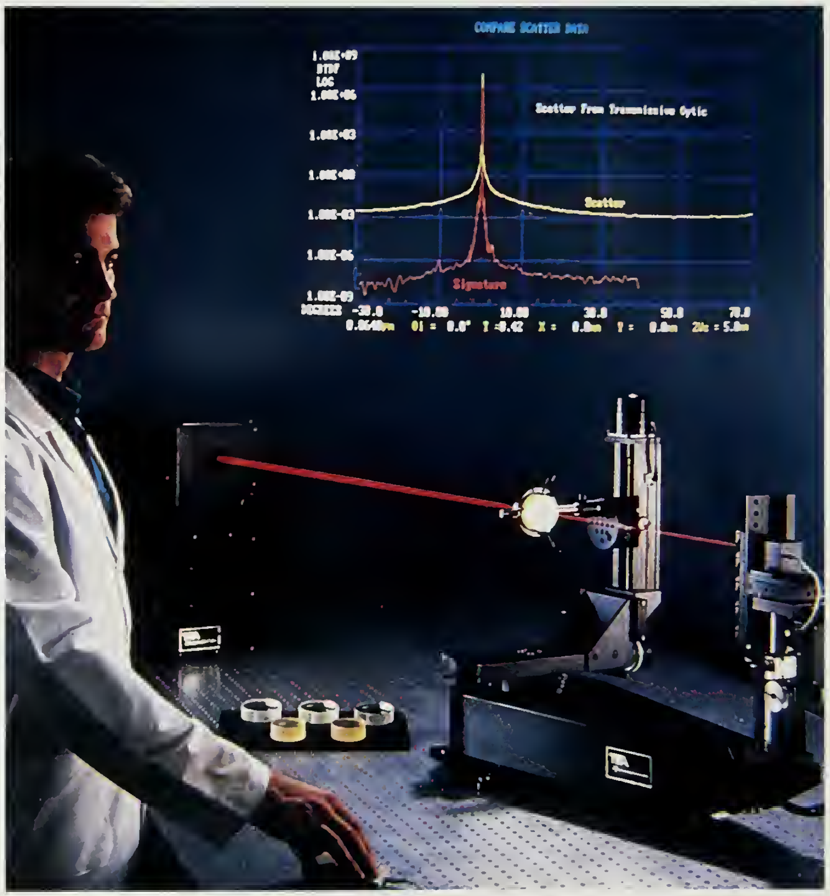
The Science and Technology Plan will position Montana institutions to participate in all of these initiatives.

FIGURE 1

MONTANA SCIENCE AND TECHNOLOGY PLAN TIME-LINES FOR IMPLEMENTATION



The Plan spells out a set of processes designed to make certain that Montanans can efficiently compete within the context of highly competitive international markets.



State-of-the-art laser instruments for measuring optical material quality are the focus of TMA Technologies, Inc.

FIGURE 2

TOWARD A BETTER FUTURE FOR MONTANA

Where the Science and Technology Plan Can Take Montanans

SHORT-TERM	MID-TERM	LONG-TERM
• CLARIFY RESPONSIBILITIES • DEVELOP PLANS • IDENTIFY OBJECTIVES • "PLAN TO PLAN"	• ENCOURAGE HIGH TECH ENTREPRENEURSHIP • ADD VALUE TO RESOURCES • SERVE INDUSTRY NEEDS • SEED RESEARCH • DEVELOP INFRASTRUCTURE • INITIATE PROGRAMS	• MONTANANS COMPETITIVE IN A WORLD ECONOMY • DESIRABLE ECONOMIC AND INDUSTRIAL DEVELOPMENT • WORLD CLASS RESEARCH IN MONTANA • ECONOMIC STRENGTH AND OCCUPATIONAL FLEXIBILITY FOR WORKING MONTANANS • NEW OPPORTUNITIES FOR MONTANA'S YOUTH • A SOUND EDUCATIONAL SYSTEM: K-100 • AN INFORMED PUBLIC

PLANNING — BUILDING THE BASICS — REACHING OUT — CLAIMING THE FUTURE

HIGHLIGHT

The Council on Competitiveness is a nonprofit, nonpartisan organization of chief executives from business, higher education, and organized labor who are concerned with the ability of U.S. companies and workers to compete effectively in world markets. Its April 1991 report, *Gaining New Ground: Technology Priorities for America's Future*, contained eleven key recommendations for assuring U.S. competitiveness in today's world economy. These recommendations are listed in the left-hand column below; the right-hand column explains how the Montana Science and Technology Plan, developed independently, nevertheless addresses all of these priorities.

THE COUNCIL'S "OVERRIDING" RECOMMENDATION:	In order to create quality jobs, generate strong economic growth and safeguard national security, the U.S. Government and private sector should work together to develop coherent policies to ensure U.S. leadership in the development, use and commercialization of technology.	Whether the U.S. Government does so or not, Montana will do so under this Plan. The Focus Groups in Part II will provide a setting for the development of specific mechanisms for interaction between government and the private sector.
GOVERNMENT RESPONSIBILITIES:	1. Make research on generic industrial technologies a national R&D priority.	The Plan does so—for generic technologies that are relevant to Montana's material, human, and institutional resources.
	2. Create a U.S. economic climate more conducive to manufacturing, innovation and investment in technology.	The entire Plan sets the stage for discussions between public and private officials who can do this in Montana.
	3. Communicate the priority of technology and competitiveness to the American public and involve key policymaking bodies more closely in the issue.	Under Part I of the Plan, Montana will be the first State to undertake such a communication program.
	4. Develop policies and programs to ensure that America has a world-class technology infrastructure.	The Plan provides means through which Montana can take the initiative relative to technology that adds value to its resources.
INDUSTRY RESPONSIBILITIES:	1. Establish more effective networks among U.S. industry groups to accelerate the diffusion of technology, facilitate commercialization, and promote leadership in critical generic technologies.	The Focus Groups, in combination with the High Technology Business Council suggested in the Background Analysis, would do this in Montana.
	2. Set a goal for U.S. firms to match and surpass the best commercialization practices of their competitors, domestic or foreign.	Part V of this Plan (University Technology Transfer) would establish a State government-university system to help Montana's industry do this.
	3. Increase direct industry working relationships with universities in key technologies.1. Develop	The Focus Groups set the stage for this in Montana.
UNIVERSITY RESPONSIBILITIES:	close ties with U.S. industry and make efforts to ensure that important technology developments are communicated to potential U.S. users on a priority, expedited basis.	Parts II and V of the Plan (Focus Groups and University Technology Transfer) would accomplish this.
	2. Make efforts, in cooperation with employees, to ensure that educational programs in engineering and management reflect the real needs of the manufacturing and service sectors.	Parts II and IV of the Plan (Focus Groups and Human Resource Development) would do this for all industrial sectors and all university programs.
	3. Keep basic science and engineering programs strong and strengthen university research capabilities so that they can adequately address fundamental, long-term research that is relevant to industry.	Focus Group 7 (Basic Research Capability) lays the groundwork for this in Montana.

Background Analysis for the Plan

MONTANA IN THE NEW TECHNOLOGICAL ECONOMY

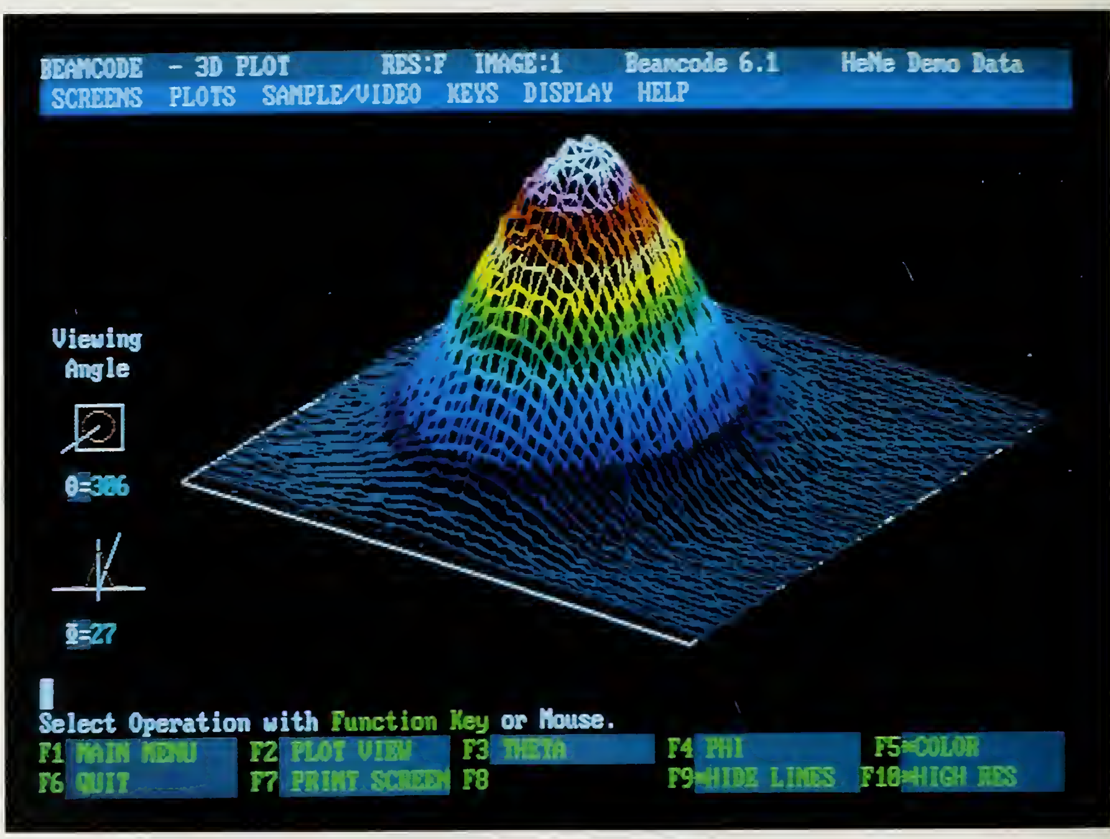
Economic Change and Its Driving Forces

Montana is often called "the last best place." But it is nevertheless a part of what others have come to describe as the "new technological economy." The key features of that economy have to do with how we communicate with each other, how we think about things (process information), and how we do things (process materials). Because they are fundamental to Montana's economic future, this analysis starts with an overview of those changes, as they are presenting themselves in today's Montana.

The most fundamental technological changes have to do with information processing and communication, represented most vividly by the personal computer. These devices, with both stand-alone and networking capabilities, are now almost universally affordable and available. The result has been called "the information society." While every society in history has relied upon information, the differences today are in the speed with which we can now process information and in the area over which it can be transmitted interactively.

Montana is already a major beneficiary of information processing technology. As it is tested and adopted in support of elementary and secondary education, it is eliminating the isolation of Montana's rural areas. It is also providing opportunities to network what have previously been independent organizations, in order to share and strengthen their resources. "Location-independent" business opportunities have opened for residents across the State, including rural areas, allowing them to profit from

Montana is already a major beneficiary of information processing technology.



Big Sky Software's three-dimensional imaging software.

transactions with wider markets while reducing their dependency on direct agricultural production. It has made it possible for technological entrepreneurs who serve worldwide markets to locate in Montana because they enjoy Montana's environment and quality of life, and not because they have suppliers or markets in the State—for many have neither.

Materials technology is a second area of great change. It, too, is having an impact on Montana. The ability to modify and adapt the products that come from the raw materials of the earth has made materials competitive with each other—increasingly so for products that people use daily. Houses can be framed and sided with steel, wood, plastics, stone, brick, or composites. Crude oil is used to generate energy and to make plastics; plastics compete with metals, wood, ceramics, and composites in different applications. Agricultural land can be used to graze cattle, raise corn, or grow trees; corn is a feedstock for ethanol, meat, or processed foods; oriented strand board competes not only with solid lumber and plywood but also with steel, plastic and sheetrock. Examples of these materials tradeoffs abound.

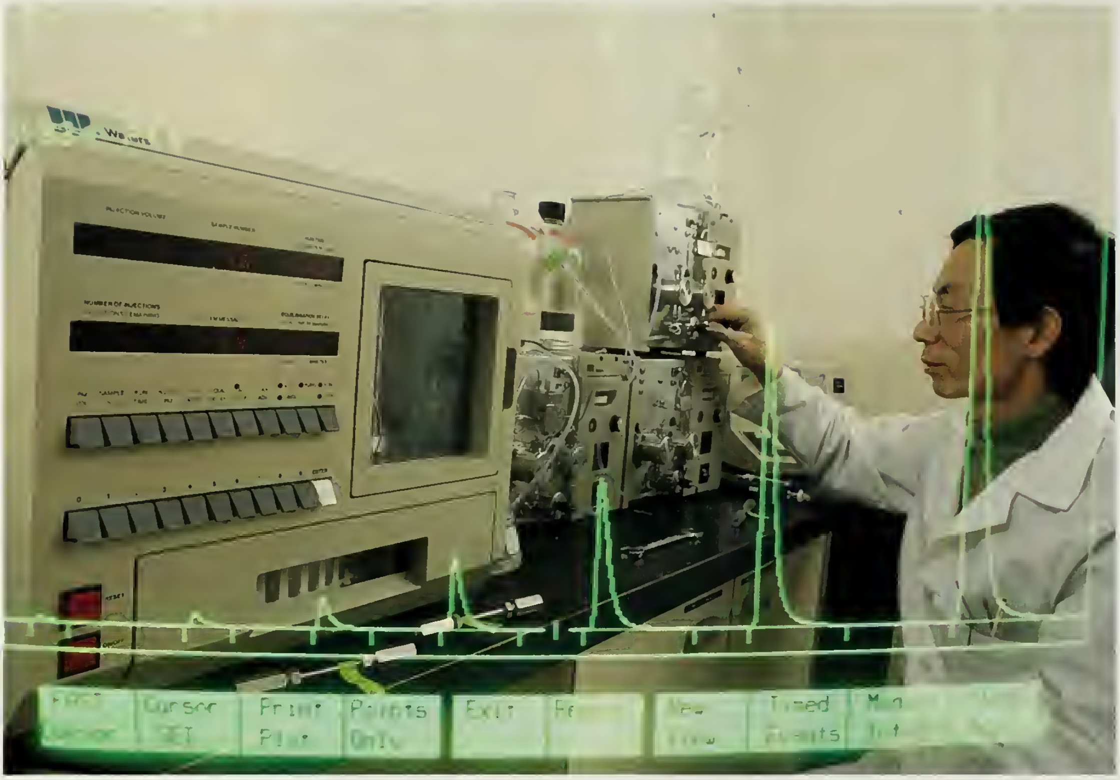
Agriculture has provided materials, as well as food, throughout history. It still produces materials, in fact more so than ever. The effects of mass processing, combined with environmental concerns, ruled Montana out of direct participation in this part of the materials industry for several decades. The information revolution is changing this, as it transforms the processes of manufacturing.

For more than a century, manufacturing has been based on what have been called "economies of scale." Most of the time, bigger was better. Cities grew as centers for making things—e.g., Detroit was once synonymous with automobiles. Centralized mass production was the rule; parts and components were made near the place where the final product was assembled. Today, however, automated manufacturing permits highly complex, sophisticated products to be assembled to customer specifications. "Just in time" stocking and production, as well as transportation costs, demand shortened lines between final production and point of delivery. Final product assembly, for mass consumption items, is moving toward population concentrations where the end product is sold and used. Similarly, and in parallel, the production of components and parts is moving toward the site of the key inputs: raw materials or, increasingly, specialized labor.

In Montana, these trends are evident in the location decisions of a growing number of small, high-value product firms that depend most heavily on the knowledge and skills of their key people. These individuals, in turn, want to live in particular locations because of the amenities they offer. Small advanced technology product and service firms in Montana "export" their wares nationwide and internationally. They are evidence of the internationalization of markets. So is the export of partially-reduced ores from

American Indian-owned West Electronics manufactures printed wiring boards for diverse markets.

Location-independent business opportunities have opened for residents across the State, including rural areas, allowing them to profit from transactions with wider markets.



ChromatoChem, Inc. technician performs quality control on its separations technology for biotechnology applications.

Biosciences and biotechnology should become a focus of both graduate education and research programs—basic, applied, and development.

Montana to Belgium (platinum) and to Texas (copper) for final processing. International trade can also be a two-way street, however: the possibility now exists to process more of the materials, and produce more of the parts and components, closer to the mines. This is especially true for processing that adds relatively high value to the material resources, yet it is also true of "medium technology" meat processing and flour milling. Modern telecommunications and information processing technology, linked to materials processing, assembly, and distribution locations worldwide, makes this possible.

Biotechnology has emerged as a field offering alternatives to mechanical, chemical, and electronic means for processing things. It also provides the possibility for additional materials. This field is looked to with anticipation by those who are concerned by the toxic environmental consequences of older means of materials processing. It is also seen as a source of advances in health care and disease prevention.

These technologies will continue to drive and accelerate the pace of change in the twenty-first century. We can already foresee, within a few years, a fully portable integrated personal computer and communication system—a matchbox mainframe or pocket Cray, coupled with a portable telephone—that can drive change as dramatically as the PC. The pace of change, which has accelerated beyond most people's imagination in the past few years, will accelerate still further—and in the same direction.

Consequences for Organizations and Operations

Modern information processing and telecommunications equipment have had two major impacts on economic organizations, and especially large ones: vertical compression and horizontal narrowing. First, they have reduced the need for middle managers by bringing chief executives and line managers closer together. Second, by improving information about what is available in the marketplace, they are leading companies to buy from outside that which they formerly provided for themselves. Big companies are scaling down and cutting back on in-house staff, spinning out suppliers and support services, and operating their remaining divisions or units as more autonomous ventures.

As a result, "professional services" is a growing category of business ventures. Coupled with the growth of high-value-added, specialty manufacturing firms, and with the separation of final assembly from component and parts manufacturing, there is today a rebirth of venturing. Contracts between organizations are replacing contracts of employment, bringing both greater independence of operations and less security of tenure. At

the same time, the final assemblers and product distributors face increased volatility in the market, especially in products and services that involve electronics and specialty materials. The marketplace demands that, in order to survive, industry must adopt technology that allows rapid, customized responses to market demand. The widespread adoption of the technology also increases the pressure to use it more effectively in order to survive economically. The result has been the development of what is now known as "niche marketing," the successor to the mass marketing that followed Henry Ford's introduction of the Model T. Niche marketing is the rule for every profitable venture in the new technological economy.

Implications for Individuals and Those Who Serve Them

Several implications for individuals are readily apparent. The first is that competence in mathematics is a basic skill and a universal requirement. Math competence means far more than simple arithmetic—computer literacy will soon be required of virtually all workers, all citizens.

Given the widened circle of social and cross-cultural contacts required (and possible) in the new technological economy, most people will also need a quality education in such other areas as the basic sciences, critical thinking, and at least one foreign language—as well as improved fluency in their native tongue. A strong foundation from kindergarten through college will be needed, and if not college then more relevant occupational training than is now generally available. Lifetime learning—the frequent retooling of personal knowledge and skills—is already a given for many people who a generation ago could have counted on lifetime occupational security within a single business or professional specialty.

As the idea of "linear careers" fades from the world of work (and eventually, even from government bureaucracies and educational institutions), there is a rise in new opportunities for technology-based entrepreneurship. The new technological economy provides, among other things, a rebirth of freedom for the self-responsible, the venturesome, the energetic, and those who also are prepared to act with knowledge and with social competence. And while all of these changes have been happening, other changes are taking place in the labor force: women and minorities (including immigrants) will comprise the majority of new workers for the foreseeable future.

It is against this background that we assess Montana's assets and deficiencies, identify opportunities and challenges, and lay the groundwork for a Plan to develop the scientific and technological infrastructure that Montanans will need to have and to share in order "to improve the quality of life, equality of opportunity and to share the blessings of liberty for this and future generations."

Competence in mathematics is a basic skill and a universal requirement. Math competence means far more than simple arithmetic—computer literacy will soon be required of virtually all workers, all citizens.

Gateway Software Corporation's library management software products are installed on computers throughout the country.

MONTANA'S ASSETS AND DEFICIENCIES

Material Resources

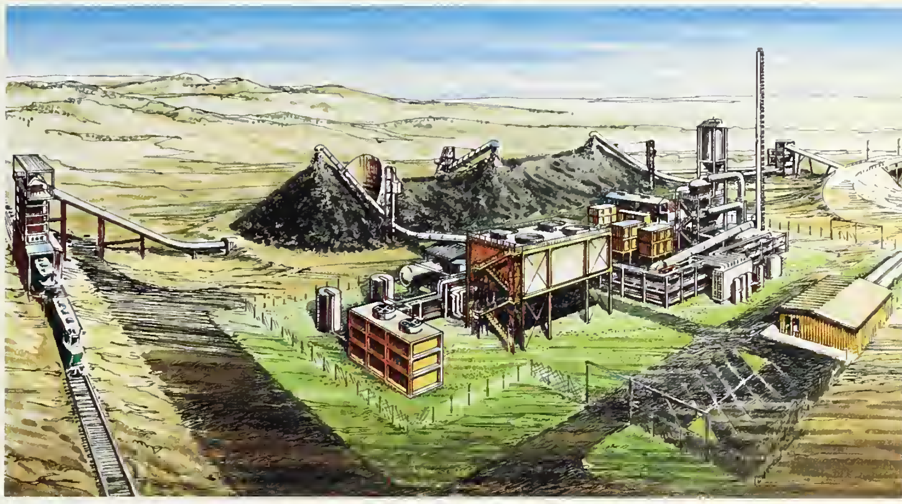
Montana has a wealth of natural resources, most of which exist as raw materials: forests and agricultural land, metals and nonmetallic minerals, and energy resources. As they currently exist, the industries that exploit these resources—agriculture, mining, forestry—are primarily extractive, with relatively little value added. As a result, most of the resulting "products" are commodities, highly vulnerable to sudden drops in world prices and loss of markets to lower-cost competition abroad. These sectors have been declining steadily over the past 20 years, in terms of both employment and labor income. But because these industries still account for 60 to 70 percent of Montana's economic base, their declining income and employment contributed to the loss of population in the State in the late 1980s.

The coal industry, for example, plays a significant role in the State's economy, both directly and indirectly. One study estimated that, in 1983, the 1,237 jobs and $459 million in sales by the coal industry produced an additional 2,293 jobs and $120 million in personal and business income elsewhere in the economy. Montana's coal deposits have a very low sulfur content, and sales have been rising, but transportation costs often make them noncompetitive. This may change in the future if proposed "green taxes" are imposed in other States, or nationwide, on polluting fuels and other environmental threats. Coal can, of course, be shipped and used in a solid or gasified state. It can also be used to make plastic, as can petroleum. Energy will be a crucial sector for decades to come, and Montana will be a major player.

Billings houses the second-largest cattle market in the Nation, even though the size of the State's cattle herd has declined in recent years. While the number of sheep has increased steadily, the prices ranchers get for lamb and wool have declined in recent years. The Montana Department of Agriculture and the

The Montana Department of Agriculture and MSU Extension Service, among others, are trying to introduce the State's growers and ranchers to new crops and new ways of marketing existing crops.

State-of-the-art Plant Growth Center at Montana State University conducts research of benefit to the State's agricultural industry.



MSU Extension Service, among others, are trying to introduce the State's growers and ranchers to new crops and new ways of marketing existing crops. For example, a Japanese consular official recently told the Montana Farm Forum that the State could increase its sales in the quality-oriented Japanese market by exporting packaged beef rather than live cattle and by shipping cleaner, higher-quality grain. Billings civic leaders and area ranchers are trying to reopen meatpacking operations, along with the related processing of hides and other by-products, but have fallen short in raising needed capital. Other potential markets for livestock are less conventional: some 37 game farms in Montana raise elk for the estimated $10 million Asian market for their antlers.

As a result of past, outmoded processes in its extraction industries, Montana has significant accumulations of waste materials that pose both economic and health concerns. Examples include mine and concentrator tailings, smelter wastes and slags, and a variety of forestry, agricultural, and livestock wastes. Yet these wastes, too, can be viewed as material resources. The Berkeley Pit, which contains 16 billion gallons of highly acidic mining wastes, is one of the largest Superfund sites and has been described as an "ecological time bomb." The Pit, which is filling at a rate of 7.6 million gallons per day, may soon reach levels that threaten drinking water in Butte and the water quality in the Upper Clark Fork River. New extraction or separation techniques are essential to the removal of this threat, as well as to the recovery of valuable materials. Other "wastes" may also turn out to be valuable raw materials—an entrepreneur in Havre is revitalizing a 35-year-old process that uses wheat and oat chaff as filler in pressboard, and several native plants that are now considered to be weeds in Montana could provide usable binders for a wide variety of applications.

The coal industry plays a significant role in the State's economy. Demand continues to grow for Montana's very low sulfur content coal.

ABOVE: Western Energy's coal beneficiation facility, now under construction in eastern Montana, will increase the marketability of Montana's coal.

LEFT: Aerial view of the Berkeley Pit, one of the largest Superfund sites.

The Berkeley Pit has been described as an "ecological time bomb." New extraction or separation techniques are essential to the removal of this threat, as well as to the recovery of valuable "waste" materials.

ILX Lightwave Corporation is located in the Advanced Technology Park at Montana State University.

Montana's clean environment and beautiful landscape are material assets. In Bozeman alone, at least three technology ventures—ILX Lightwave, Lattice Materials, and Skyland Scientific—have moved to the State precisely for landscape and lifestyle.

Recent forecasts anticipate continued decline, or at best stability, for most of these sectors. New extraction processes can reverse this decline. But they are unlikely to cause a new boom, or to create large numbers of new jobs for Montanans, unless they are accompanied by significant increases in value-added follow-on production. By contrast, the retail trade and service sectors have been growing steadily in both employment and labor income. In fact, services is the only employment sector that has increased consistently in each of the last 10 years. The Montana Department of Labor and Industry estimates that the services sector will generate 87 percent of the new jobs in the next 10 years, coincidentally coming to represent 87 percent of all employment in the State by the year 2000. Health services and educational services are currently the fastest growing job categories in the State. Growth in retail trade, however, cannot be sustained without growth in more basic industrial sectors. Similarly, health and educational services can be supported adequately only from a base of profitable primary industry.

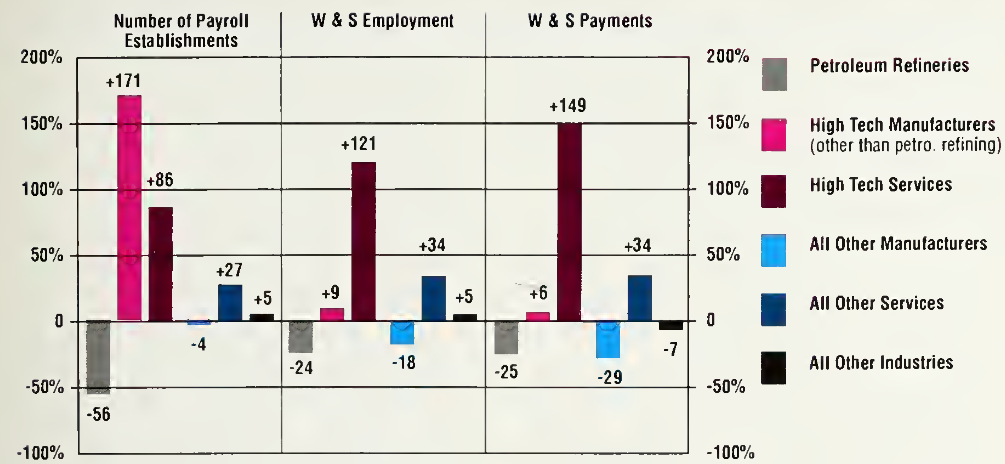
Montana's clean environment and beautiful landscape are material assets, as well, and tourism is the only "natural resource" industry that has grown in employment and income over the past 20 years. There may be limits to the number of tourists who can be accommodated without trashing the very landscape that attracts them. On the other hand, Montana's natural beauty and recreational availability have proven appeal for the entrepreneurs, technology professionals, and skilled workers whose presence in Montana is required for the new technological economy. In Bozeman alone, at least three technology ventures—ILX Lightwave, Lattice Materials, and Skyland Scientific—have moved to the State precisely for landscape and lifestyle. Recent nationwide trends also suggest that a new breed of young, vigorous retirees is settling in areas like Montana that offer natural beauty and low living costs; these individuals, too, can add valuable skills and experience to a workforce that has been depleted by the out-migration of so many of its youngest, best-educated workers.

Lattice Materials Corporation provides value added fabrication and characterization of its crystal products.

Montana's natural beauty and recreational availability have proven appeal for the entrepreneurs, technology professionals, and skilled workers whose presence in Montana is required for the new technological economy.

High Tech Industry Growth in Montana

Percent Change, 1979 - 89



Share of Overall Activity

		1979	1989
High Tech manufacturing (other than petro refining) as a percent of all manufacturing	W & S Employment	3.8%	4.9%
	W & S Payments	3.7%	5.4%
High Tech services as a percent of all	W & S Employment	0.7%	1.2%
	W & S Payments	1.0%	1.9%
All High Tech industries as a percent of all industries	W & S Employment	0.9%	1.0%
	W & S Payments	1.4%	1.6%

SOURCE: Bureau of Business and Economic Research, University of Montana (using State Department of Labor and Industry wage and salary data)

Human Resources

Montana has an exceptionally well educated workforce, largely due to a highly effective K-12 education system. However, only half of its high school graduates go on to college, and half of them go out of State. Many of these students do not return, and many who do go to college in Montana also leave the State after graduation. On the other hand, Montana also has a significant number of entrepreneurs, and additional entrepreneurs are being attracted by the workforce and quality of life. However, technological entrepreneurship is constrained by a number of financial, institutional, and policy burdens. Many of Montana's homegrown entrepreneurs are entrepreneurs by necessity, and they need strong technological assistance if they are to be competitive.

K-12 Education.—Montana's workforce is one of the most literate and work-oriented in the Nation. The State ranks 44th in total population and 48th in population density, yet it ranks 4th in percentage of high school graduates (87.3 percent, compared to a national average of 71.1 percent) and 4th in adult literacy (92 percent). Testing by the military also shows that inductees from Montana are of consistently high quality.

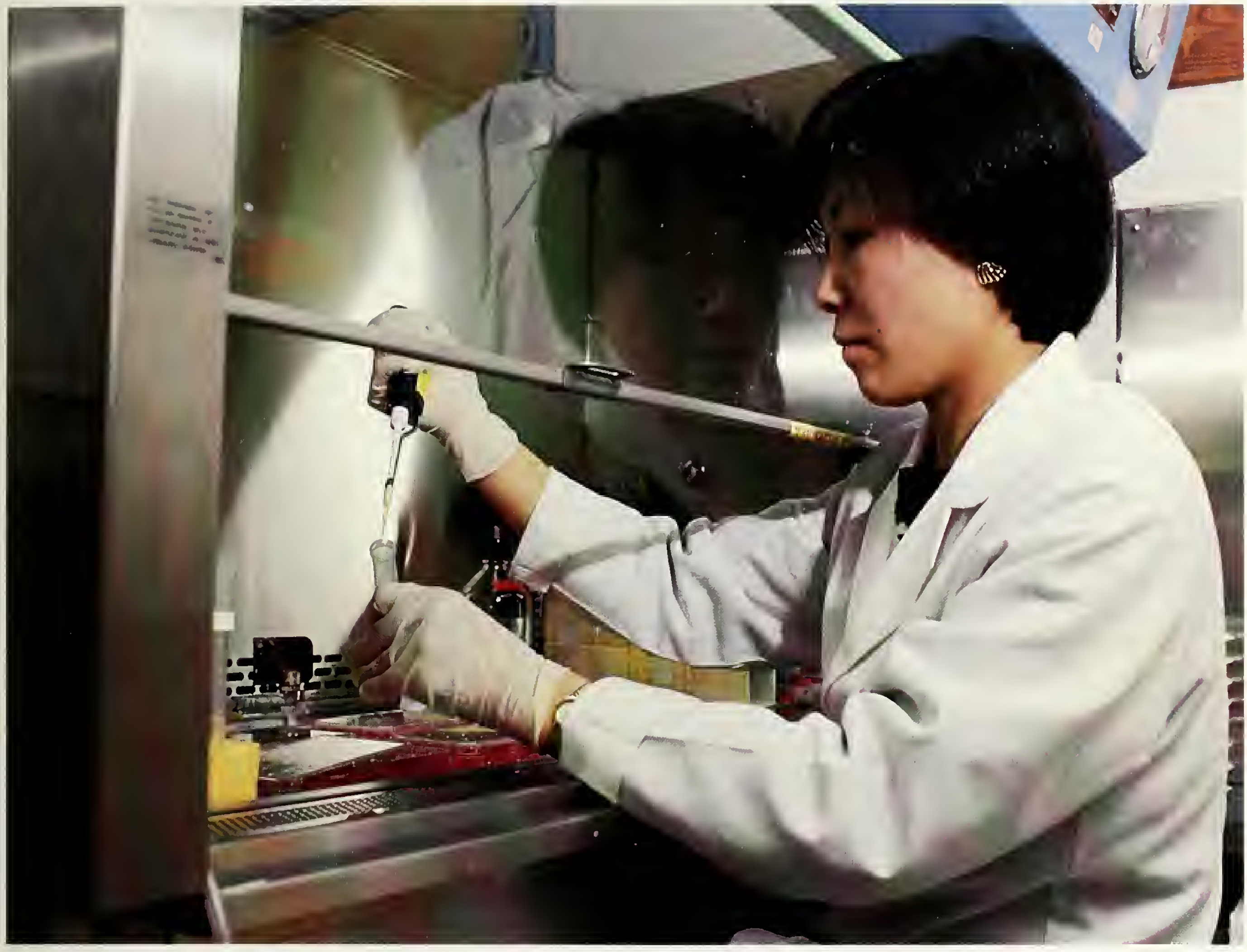
Much of the credit goes to its outstanding public education system, which is one of the best in the United States by any measure. Montana's total (State plus local) expenditures for K-12 education, both per student and per capita, are consistently among the highest in the Nation. And the system is effective—Montana students score considerably higher than the national average on standardized achievement tests, with particular strength in mathematics and natural science. An important factor is the involvement and sense of ownership by parents at the school and district level.

Montana is also a pioneer in educational applications of advanced telecommunications. It is providing both alpha and beta test sites for major national initiatives to introduce advanced telecommunications into remote areas. Examples include interactive systems and distributed resources—in one district, for example, five foreign language teachers are located in five different schools, but students at all five schools are able to take the language training of their choice through interactive links. The Montana Educational Telecommunications Network (METNET) provides a wide variety of computer-based and video programs to local schools for student courses, teacher in-service training, and enrichment activities.

Higher Education.— Montana's support for higher education does not match its achievements in K-12. Expenditures for higher education, at $214 per capita or $4,300 per student in 1986, ranked 29th among the States. Expenditures for higher education increased only 12 percent during 1970-1986, while K-12 spending increased 59 percent. Nevertheless, State spending for higher education in Montana is roughly comparable to that of its neighboring States, except Wyoming.

In addition, students at Montana universities are not able to use the same level of telecommunications they have become accustomed to in their high school careers. The State's colleges and universities do not use the National Technological University (NTU), and the ability to share resources among campuses within the State is limited—the only example we found was a link between Missoula and Billings for business courses. Telecommunications links between the universities and high schools—Big Sky Telegraph and MSU's computerized science classes—are more extensive than those for intercampus use. Anecdotal evidence suggests that university-level teaching facilities and equipment, generally, are inferior to those that many students used in high school.

However, Montana's university students do well. *USA Today* recognized three MSU students among the top 30 in the Nation for 1990-1991. UM is a leader in graduating future Rhodes Scholars. Montana Tech has an enviable list of alumni in *Who's Who in America*—as well as one of the best small college science programs in the United States. Yet 80 percent of the graduates of the MSU School of Engineering find their first jobs outside the State. Some of these Montanans later return to the State, and many others might do so if



they were able to find adequate economic opportunities, or if their education had focused on in-State opportunities.

Despite their high literacy rate, only 21 percent of Montana workers have four years of college (23rd among the States). Far more limiting, from the point of view of this study, the State has only 29.3 scientists and engineers per 1,000 population (47th). Evidence suggests that there is an acute personnel shortage in engineering as it relates to design and manufacturing—fields that are required if Montana is to attract or develop processing and manufacturing ventures. Efforts to retain and recruit "high-end" professionals should also increase the number of potential technological entrepreneurs in the State.

While anecdotal evidence suggests that university-level teaching facilities and equipment, generally, are inferior to those that many students used in high school, Montana's university students do well.

Center of Excellence in Biotechnology researcher utilizes laboratory facilities at the University of Montana.

The State also has shortages of key technical workers: in early 1991 over 100 jobs requiring technical skills (e.g., engineering, technical management, computer programming) were widely advertised for months without being filled.

Entrepreneurship.—Montana already has a significant number of entrepreneurs, and additional entrepreneurs are being attracted by the workforce and quality of life. About 3,000 new businesses were established in Montana each year during the 1980s, over half of them in services (especially business and health services) and in retail trade. A study by the Montana Department of Labor and Industry showed that 43 percent of the businesses established in 1983 were still alive five years later—a respectable survival rate nationwide. Engineering, Accounting, Research, Management, and Related Services had the highest survival rate (79 percent), followed by Health Services (70 percent). Both of these are promising for the future, given the need for these services to support both basic industry and a healthy population. By contrast, manufacturing firms had a poor survival rate overall (38.5 percent), and only 17 of 79 startups in Mining (21.5 percent) survived their first five years. However, further study might be in order to determine how many of these "failures" were planned from the start, to exploit either a particular, limited resource or a short-term opportunity.

Western Montana is one of three areas in the nonmetropolitan West that have seen a recent increase in the number of "distance-independent high technology industries." Many of these technologically advanced enterprises, which often have neither suppliers nor customers in Montana, are moving to or starting up in cities near the State's universities. However, new businesses with regional markets are also springing up in rural areas. Two examples that have attracted nationwide press are Advantage Line, a telemarketing firm that operates from a ranch near Wolf Point, and Glacier Nursery, located in Kalispell.

Other data on entrepreneurship sends conflicting messages. Montana rates higher than any other State in women and minority business ownership (American Indians are not included in this measure, developed by the Corporation for Enterprise Development). It ranks only 23rd in the number of new businesses founded per 10,000 workers and 47th in the index of fast-growing companies. These statistics do not capture the great number of "microenterprises" with less than 10 employees, but anecdotal evidence suggests that many marginal microenterprises in Montana exist because the proprietors have no alternative for employment or income. Many enterprises that would be nationally owned or

Key Technologies

Priority areas as defined by the U.S. Office of Science & Technology Policy, March 1991.
Boldfaced areas are ones in which Montana has or can develop capability.

Materials	Biotech	Manufacturing	Information & Communication Software	Aerospace & Transportation	Energy & Environment
Synthesis & processing	**Applied molecular biology**	**Flexible manufacturing**	**Microelectronics & optoelectronics**	Aeronautics	**Energy**
Electronics and photonics	**Medical technology**	**Intelligent processing equipment**	**High-performance computing & networking**	Surface transportation	**Pollution minimization & remediation**
Ceramics composites		Micro- & nano-fabrication	High-definition imaging & displays		
High-performance metals		Systems management	**Sensors & signal processing**		
			Data storage & peripherals		
			Computer simulation & modeling		

SOURCE: Washington Technology, *March 21, 1991*

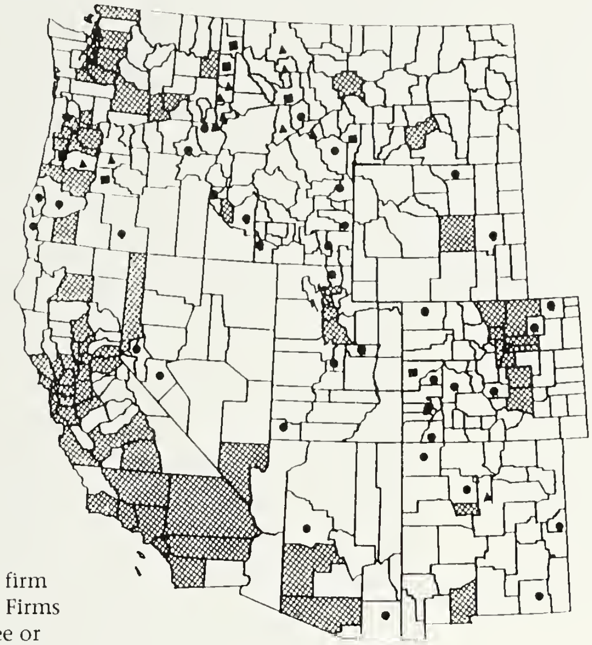
franchised in other States (e.g., restaurants, car rental) are locally owned in Montana, but few Montana companies have made use of franchising to expand their operations beyond the State. In short, Montana companies tend to start small and stay small; the State's small business sector is surviving, not expanding.

Technological entrepreneurship in Montana is restrained by a number of factors. There is a lack of local capital at the seed and startup phases, and few outside venture capitalists look to Montana for investment opportunities. The State has few individuals who combine the business and technological skills needed to evaluate advanced technology from a commercial standpoint. It also has shortages of key technical workers: in early 1991 over 100 jobs requiring technical skills (e.g., engineering, technical management, computer programming) were widely advertised for months without being filled. Startup companies also have difficulty gaining access to both management and technological support resources in the State, especially in a coordinated manner. Montana imposes a high tax burden on the (usually high-cost) equipment involved in advanced technology enterprises. And above all, the entrepreneurs who would create new economic opportunities for other Montanans are burdened with high worker's compensation taxes resulting from the past failures of dead or dying industries.

All of this points to at least a partial lack of the human and institutional infrastructure for participation in the new technological economy. The existing structure of the State of Montana's Executive Branch does not provide for a results-oriented group or official with the authority and competence to be a driving force in support of technological entrepreneurship. And there is little evidence that the general population or the political leadership has an effective understanding of the significance of science and technology as they relate to the future of Montana's economy. The tendency is still to think of new technology as the basis for new jobs, when it is actually reshaping every existing job and becoming a prerequisite for the formation and survival of most new ventures.

High Tech Entrepreneurs in the Nonmetro West

A recent study sought to identify recently founded (between 1976 and 1986), locally owned and operated (non-branch), locally-generated (not previously located in another community) high technology firms located in non-metropolitan areas of the Western United States. Locations are indicated on the map.



- ● One firm
- ■ Two Firms
- ▲ Three or more firms
- ▩ Metro Counties*

* Counties with a population concentration of at least 50,000 people in the 1980 Census.

SOURCE: Barkley, Smith and Coupal, 1990 (*High Tech Entrepreneurs in the Nonmetro West: Who is Starting What?*. Western Rural Development Center, Oregon State University, Corvalis).

Institutional Resources

Montana has in place at least some of the institutional resources needed to support its participation in the new technological economy. Their strengths are qualified, however, and many deficiencies exist. These organizations are not well networked, for example, impeding user access and reducing overall impact. Furthermore, the resources of Federal laboratories within Montana have not been tapped to a significant degree, and university policies are viewed as an obstacle by some technological entrepreneurs. Strengthening and coordinating these institutional resources should be a high priority.

The tendency is still to think of new technology as the basis for new jobs, when it is actually reshaping every existing job and becoming a prerequisite for the formation and survival of most new ventures.

Montana graduates do not necessarily have all the skills they need for the openings in existing industry, let alone those needed to support increased industrial activity in the State. Course opportunities do not always prepare for the opportunities that already exist.

CAD/CAM educational center at Northern Montana College provides training for Montana students and entrepreneurs.

K-12 and Vocational-Technical Education.— Montana's K-12 education system is a national leader, especially in science and math education, and a cutting-edge user of advanced telecommunications technology. Parents are fiercely interested in the quality of education for their children through grade 12. However, there appears to be a lingering feeling among many Montanans that a high school education is enough.

Montana's vocational-technical education program is currently undergoing a major reorientation. The transfer from local to State control is not complete but is making progress. There is a promising shift towards occupational focus, especially in Butte and Helena, but many Vo-Tech offerings still look backward rather than forward. Graduates do not necessarily have all of the skills they need for the openings in existing industry, let alone those needed to support increased industrial activity in the State. Localized shortages of key skills exist—e.g., electronic assembly in Bozeman. There is a need for greater interaction between Vo-Tech and industry, which continues to train many of its own workers. Many of Montana's young people seek their technical training at private institutions out of State or from the military.

Colleges and Universities.— Undergraduate education in Montana's colleges and universities is strong relative to their small size. The achievements of its students—mentioned earlier—is noteworthy. Yet course offerings do not always prepare for the opportunities that already exist. Further, information made

publicly available by the universities for student recruitment (e.g., to Lovejoy's catalogue) does not reflect the true breadth and depth of their own offerings and resources. These institutions do not enjoy the same level of support inside Montana that K-12 education does. But what is most visibly lacking is strong financial support for the universities from private industry, especially from outside the State.

Graduate education is strong in areas that correspond to research strengths, largely due to the efforts of faculty and/or administration intrapreneurs. Each of the State's three "technological" universities lacks equipment and facilities that would make it attractive to the industry it should be serving. Mineral, biological, veterinary, and agricultural sciences are strong— yet largely untapped in relation to their potential.

Beyond the K-12 level, the principal drivers for institutional resources are intrapreneurs who must act opportunistically rather than strategically. This is good, but insufficient. As a result, these organizations do not always provide the services to industry that they might, and relatively few efforts have been made to coordinate their various services and activities for the convenience and quality of user access. The Montana Commission on Higher Education for the 1990s recommended a greater networking of educational resources, and in fact there are the beginnings of cooperation between K-12 and the universities. Montana's Tribal Colleges are part of a seven-State network that has considerable promise. But these are only beginnings.

Research Capabilities and Centers.—Prior to the establishment of the current centers of excellence, most university research in Montana was conducted on a project basis, tied to individual grants and individual researchers or small teams. Such project research will remain an essential part of any strategy for tapping the intellectual resources of the universities. The Federal government (through the National Science Foundation's EPSCOR Program) has "seeded" the development of basic science research capability in Montana, to the point that numerous researchers are now able to compete nationally for major basic research grants. Congress recently extended EPSCOR to other Federal agencies, making $30 million per year available for similar purposes. Montana's universities should exploit these funds—particularly those coming from the Departments of Energy and the Interior, the Environmental Protection Agency, and the National Institutes of Health—which can be used to attract additional applied research dollars in areas of concern to the State's industry.

Most Montana business and industry leaders feel that State support for research should focus on applied science and technology. At some point, however, Montana will be ineligible for further EPSCOR funds from NSF to seed the development of research capacity. This calls for a strategy of using some State funds to "seed" basic capabilities (while relying on national sources for the bulk of basic research funds) and concentrating most State funding on areas of particular, demonstrable value to Montana.

The centers of excellence, on the other hand, provide a mechanism for creating critical mass and focusing attention on areas of particular importance the State's economy. As they currently exist, the State's four "centers of excellence" are uneven, particularly in terms of both industry participation and the extent of actual research:

Center for Interfacial Microbial Process Engineering is the recipient of a $7.5 million National Science Foundation engineering research center grant.

The Center for Interfacial Microbial Process Engineering is organized and operated as a true center of excellence—focusing effort, getting industrial support, addressing industry's concerns.

U.S. Department of Interior's Fish Technology Center in Bozeman, Montana, can duplicate conditions in any fish hatchery in the United States.

The Fish Technology Center represents a major opportunity for technology transfer—a potential nucleus for commercial aquaculture and fresh-water fisheries industries in Montana and an opportunity for an allied commercial aquaculture support industry with a nationwide market.

- The Center for Interfacial Microbial Process Engineering is organized and operated as a true center of excellence—focusing effort, getting industrial support, addressing industry's concerns.
- The Center for Advanced Materials at MSU is structured to pursue projects of high interest to the national scientific community, but it nevertheless has economic value, especially in the long term and in relation to electro-optics.
- The Center of Excellence in Biotechnology, while it cannot be called a "center of excellence" in the usual sense, performs a useful coordinating role and could provide the foundation for a true research consortium in the future.
- The Advanced Minerals and Hazardous Waste Processing Center can become a "center of excellence," in the usual sense, if it is able to build on its involvement in the new "Wastec" center, for which Federal funding is being provided through the U.S. Environmental Protection Agency and Department of Energy.

In addition, policies on university-industry relations and intellectual property vary considerably among the universities, but are widely viewed as an obstacle by technological entrepreneurs. And there is a much broader need to increase the competitiveness and commercial relevance, as well as the accessibility, of university research and development activities. Montana has applied few of the techniques for university technology transfer that have been developed and applied elsewhere. In forestry and mining, for example, support is not as forthcoming for promising new "downstream" processes as for traditional extraction processes. University-based research involves indirect costs, which cover administrative and institutional costs not directly associated with the research, but which are subject to reimbursement by research sponsors. Retention of indirect cost reimbursement at the universities has been and will remain necessary to build the research capacity at the universities to respond to these industrial needs.

Federal Laboratories.— A number of Federal laboratories and research centers in or near Montana offer resources that complement the State's. However, these opportunities for technology transfer remain largely unexploited. The Federal Technology Transfer Act of 1986 specifically authorizes such interactions for industrial technological applications. The present participation by Montana institutions with Rocky Mountain Laboratories and the Idaho National Engineering Laboratory is programmatic, rather than transfer oriented. There is little or no interaction with the U.S. Department of Agriculture's Research Station at Sidney or

the Intermountain Fire Sciences Laboratory at Missoula, which operates the largest open-combustion research facility in the United States. The Fish Technology Center in Bozeman, which can duplicate conditions in any fish hatchery in the United States, represents a major opportunity for technology transfer—a potential nucleus for commercial aquaculture and fresh-water fisheries industries in Montana, and an opportunity for an allied commercial aquaculture support industry with a nationwide market.

In other States where Federal laboratory resources have been successfully tapped for transfer, leadership has come from an individual "catalyst" within the laboratory, the State government, or the local community. Access to Federal laboratories can provide technical assistance, but can also lead to the formation of consortia for joint or cooperative research. The latter often leads to the creation of formal centers and the spawning of new technology ventures. Examples include State-sponsored collaboration in Illinois among Argonne, Fermilab, and the University of Chicago; the creation of five centers of excellence (now self-sufficient) in New Mexico's "Rio Grande Corridor"; and successful State-sponsored centers in space technology in Ohio, agriculture in Illinois, and toxicology in Arkansas, all of which leveraged the resources of a Federal facility for purposes of economic development.

Beyond the Federal laboratories, Federal interest in local (especially rural) development presents both opportunities and challenges. In 1990, for example, the Forest Service was authorized to use 5 percent of its commercial revenues for rural development in the States to which they are attributable. Subject to Federal appropriations and the development of effective proposals, this funding could be used to support the development of alternative and innovative technologies that will create new economic opportunities in the rural, forested areas of Montana. On the other hand, the Federal Rural Development Act establishes a new set of relatively independent "economic developers" in the Federal bureaucracy, including one located in each National Forest. In these and other cases, the State must exert leadership to ensure that Federal action does not lead to fragmentation or subversion of local initiatives or to the distortion of actual needs and responses.

The Montana Science and Technology Advisory Council is a first step toward overall coordination of policy among the private and public performers of research and development, the industrial users of science and technology, the underlying educational institutions, and economic development interests. A permanent structure deserves consideration.

Policy Oversight and Networking.—Also to the point, the State has provided little if any overall guidance and support for science and technology. A number of relatively independent organizations serve as resources for institutional networking, entrepreneurship support, and technology transfer—the Montana Science and Technology Alliance, Montana Entrepreneurship Center, MSU's University Technology Assistance Program (UTAP), industrial extension activities at Northern Montana College, USDA Cooperative Extension Service, Small Business Development Centers, etc. But the State has appropriated less than $10,000 over five years to UTAP, where industry access to university resources must be handled by part-time employees. Northern Montana's industrial modernization assistance efforts have been useful, but limited.

In addition, there is a disconnect between management support (for entrepreneurs) and technical assistance (for existing industry). Significantly, the technology transfer responsibilities of MSTA have been unfunded for at least four years. The coordinating role of the "centers of excellence" has been positive, although limited to the disciplines they address. On a larger scale, the Montana Science and Technology Advisory Council is a first step toward overall coordination of policy among the private and public performers of research and development, the industrial users of science and technology, the underlying educational institutions, and economic development interests. A permanent structure deserves consideration.

CHALLENGES AND OPPORTUNITIES

What is needed in most cases, therefore, is not a new program or entity but rather increased support for and coordination among existing activities. There are, nevertheless, some voids waiting to be filled.

Given these assets and deficiencies, and given the requirements for successful participation in the new technological economy, Montana must now respond to several challenges and opportunities. These are discussed below in the same terms—material, human, and institutional resources—although there is considerable overlap between sectors and indeed among individual items. In several cases, an existing organization or activity is already addressing the need, or exploiting the opportunity, to some degree. Such organizations provide both a model and a nucleus for further action. What is needed in most cases, therefore, is not a new program or entity but rather increased support for and coordination among existing activities. There are, nevertheless, some voids waiting to be filled.

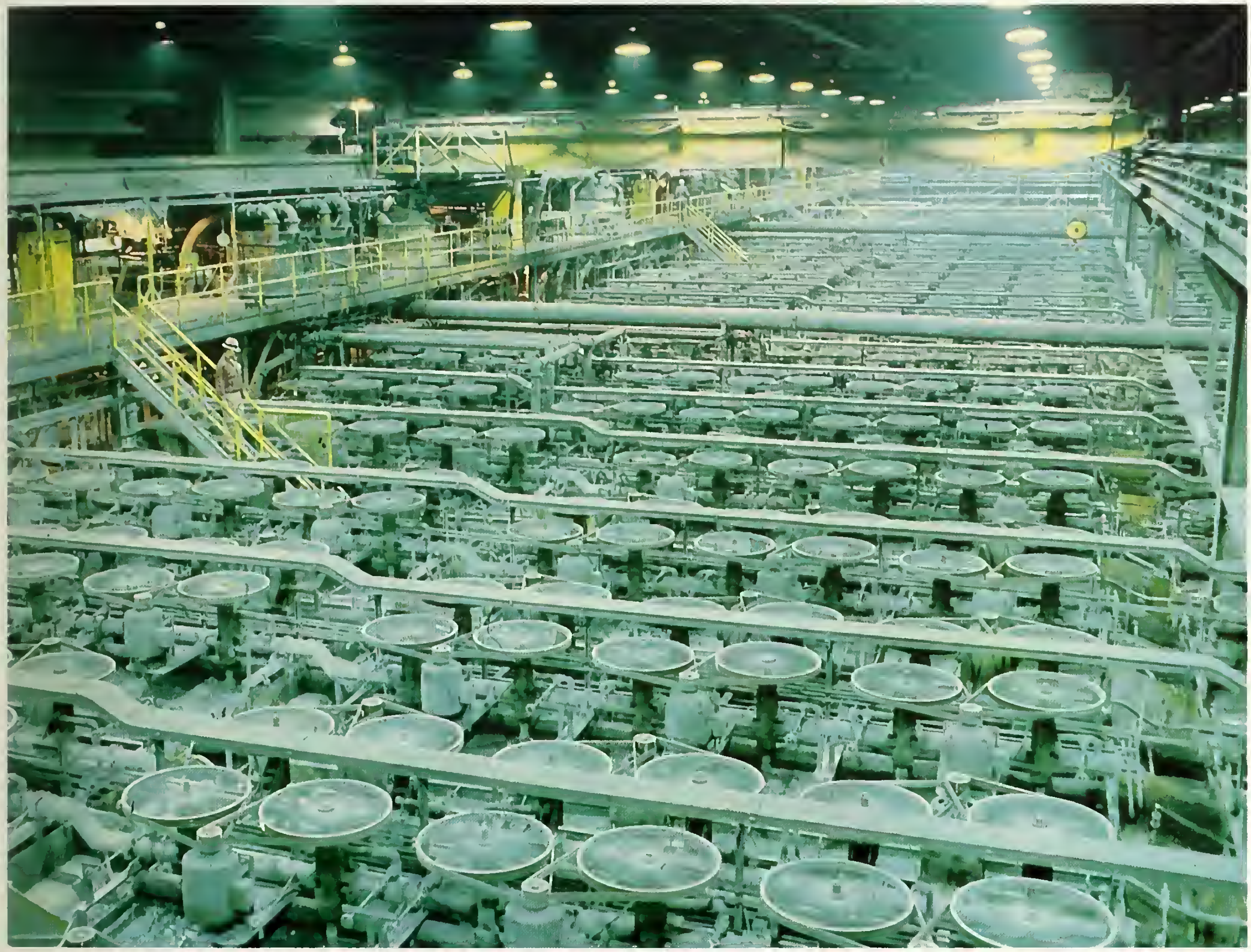
Materials

CHALLENGE: Develop a new way of looking at Montana's economy.—Montana needs to move further along the "value-added spectrum." Specifically, the State needs to establish and develop a materials capability, including both research and applications, and spanning traditional industries. For example, "energy resources" (coal, petroleum, natural gas) are in fact raw materials for both energy and tangible product applications; "processing" includes both primary extraction and extraction from wastes, as well as the stabilization of waste materials. Progress in these areas will find new uses and applications for Montana's material resources, increasing their value and creating or preserving employment opportunities in the "materials sector." These and other areas relevant to Montana's social and economic needs and opportunities should therefore become the focus of both graduate education and research programs—basic, applied, and development. In the short term, this means waste conversion, materials processing, and resource utilization. In the middle term it means biosciences and biotechnology, in a wide range of applications. In the longer term, it also includes physics, communications, and biosciences/biotechnology.

Specifically, the State needs to establish and develop a materials capability, including both research and applications, and spanning traditional industries.

OPPORTUNITY: Strengthen and extend research capabilities, including centers of excellence.—This means improving not only their finances but also (more so) their ability to conduct industrially relevant research and become involved with industry in applications. In all of the centers, for example, there should be mechanisms for matching university activities with the actual needs of industry. Only the Center for Interfacial Microbial Process Engineering at MSU (an NSF Engineering Research Center) has significant funding and participation by industrial sponsors. The Advanced Minerals and Hazardous Waste Processing Center of Excellence at Montana Tech needs to be a major partner in the "Wastec" initiative, along with Montana Technologies and other private firms. The existing Center of Excellence in Biotechnology could become the nucleus for a true performing center of excellence, pursuing applications to Montana's natural resources, including wastes, as well as health care applications. Launching such a center might require an investment of $10 million or more over five years. As much as $3 million of this amount might come from NIH, and additional amounts could be provided "in kind" by Montana firms. This investment could conceivably bring into the State up to $30 million in subsequent grants and research contracts, without even considering commercial spinoffs.

The initial processing of raw materials is moving closer to the point of extraction.



Biosciences and biotechnology should become a focus of both graduate education and research programs—basic, applied, and development.

ABOVE: Montana Resources, Inc. mineral processing facility.

LEFT: Basic Bio Systems, Inc. investigates potential applications for the company's controlled-release NURTURE system.

Human

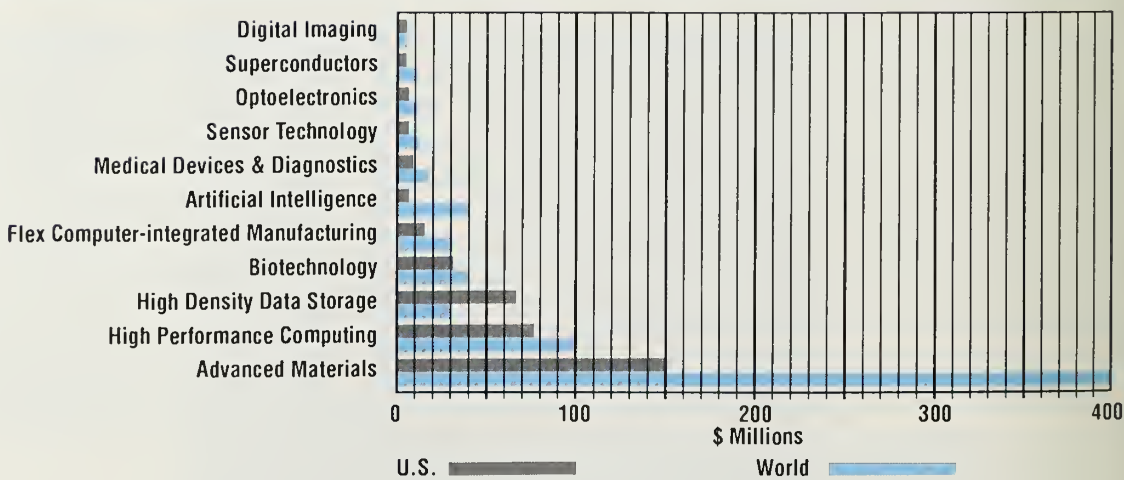
Specifically, the State should continue to upgrade and expand its educational telecommunications network and to target parents with a technology awareness program. This degree of leadership should also be extended to all subsequent educational programs in other institutions.

CHALLENGE: **Continue and extend Montana's leadership at the K-12 level.**—Montana is a leader in both (1) science, math, and technology education and (2) the use of advanced communications and information processing technology. Nevertheless, efforts are justified to improve teacher training in science and mathematics, and to provide these teachers with additional tools and resources. Specifically, the State should continue to upgrade and expand its educational telecommunications network and to target parents with a technology awareness program. This degree of leadership should also be extended to all subsequent educational programs in other institutions.

CHALLENGE: **Develop a "critical mass" of talent in science and technology fields that relate to the needs of industry.**—This will require stable and continuing support for all university functions (including salaries, facilities, equipment to attract qualified faculty), but especially for the seeding of fundamental research and study of national quality (e.g., State matching funds for EPSCOR), in areas and in ways that support industry and economic progress. It will also require efforts to improve the quality and relevance of the Vo-Tech centers and the Tribal Colleges, specifically by involving industry in the development of job-specific training curricula for the Vo-Tech centers and improving the quality and sharing of resources for and among the Tribal Colleges. Such programs as American Indian Research Opportunities (AIRO) provide a starting point for the latter.

OPPORTUNITY: **Recruit people, not plants.**—Discontinue "smokestack chasing." Industrial location decisions in the new technological economy are increasingly people-oriented, as well as bottom-line oriented, within the framework discussed at the start of this analysis. Montana should recruit people and firms from out of State who will provide the nucleus and support for advanced technology enterprises in Montana. Examples include distance- and location-independent entrepreneurs, the operating heads of ventures (corporate divisions) that process Montana's materials, engineers, venture capital "angels," skilled retirees, and other technological professionals. Montana should take steps to retain and encourage these people and firms if they are already in the State, and to bring former Montanans and university alumni "home" if they have skills to contribute to the continued development of the State's economy.

Department of Commerce "Annual Sales Predictions for 2000"



SOURCE: Washington Technology, *November 1990*

OPPORTUNITY: Pursue appropriate high-profile scientific projects.—The strong physics program at MSU offers Montana an opportunity to participate and indeed play a central role in a major national and international science program, the Laser Interferometer Gravitational Observatory (LIGO). Participation in LIGO would bring Montana considerable scientific prestige, as well as related economic growth around the new $100 million facility. Support from this sort of program is also needed to maintain a competitive in-state science capability and to support industry needs in the new technological economy. The Montana Department of Commerce and the MSU Physics Department have formed a task force to pursue this project, which would bring particular benefits to the Bozeman and Billings areas.

OPPORTUNITY: Prepare the public for the new technological economy.—A broad educational program is needed to cultivate public awareness of new economic realities and their significance to Montana. An important goal would be to increase public awareness of the contributions already being made by the State's universities and colleges, and its existing businesses and industries, as well as their potential role in making the transition to the twenty-first century. These efforts should draw on industry support and feature Montana firms and individuals as tangible evidence of what is happening in the State. The campaign might well include video presentations and public service announcements through the media, local seminars involving legislative and civic leaders, and programs for civic groups and in the schools. Possible resources for such a campaign include the "Society and Technology" degree program at Montana Tech; the "Which Way to Tomorrow?" workshops sponsored by the Flathead Economic Development Corporation and Kalispell Area Chamber of Commerce; the proposed joint public television initiative by UM and MSU; and local cable, broadcast, and publishing media.

Institutional

CHALLENGE: Strengthen and coordinate existing institutional resources.—At least some of the required institutional resources are in place. But these organizations are poorly coordinated, and many potential resources remain untapped. Strengthening and providing cross-access to these institutional resources should be a high priority.

OPPORTUNITY: Convene statewide "focus groups" to set the agenda for cooperation among sectors, including the development of research agendas.—There is at present no forum for continuing intersectoral discussion of the issues raised by this report. Participants would include industry, K-12 and university educators, community groups, executive and legislative branches of government, and representatives of Federal laboratories and out-of-State corporations with an interest in Montana. Convened by the Governor, in a nonpartisan setting, these groups would represent a fast first step toward identifying common interests and concerns. Over time, they could become an effective mechanism for sharing information and resources; in some cases they might also provide the nucleus for collaborative research programs and centers. As a minimum, focus groups should be developed in the following areas:

- mineral extraction and processing;
- forestry and wood products;
- agriculture (with subgroups for crops and livestock);
- energy resources;
- biotechnology and its applications;
- communication and manufacturing processes and technology; and
- basic science capacity.

Discontinue "smokestack chasing." Industrial location decisions in the new technological economy are increasingly people-oriented.

Research in immuno-stimulants is ongoing at Ribi ImmunoChem Research, Inc.

Focus groups, such as one in biotechnology, are an effective mechanism for sharing information and resources and provide the nucleus for collaborative research programs and centers.

OPPORTUNITY: **Improve the transfer of university expertise and technology to the public.**—Given Montana's large distances and small population, it must make the maximum possible use of networking for resource sharing among relevant institutions. The necessary telecommunications technologies already exist, and Montana is a leader in their applications at the K-12 level. The use of these technologies and techniques should be expanded to network and integrate the State's institutional resources in the following areas:

- a new "K-16" partnership between K-12 and the universities;
- undergraduate education (upgrade through resource sharing such as MUSENET);
- graduate education and in-service professional education (including off-campus, off-hours training and systems like the National Technological University);
- lifelong learning for skill maintenance and career changes, as well as the needs of the general population;
- science base for research at institutions of higher education (e.g., funds for startup and carryover, subsidies for targeted research);
- research and development (improved access to university, Federal, and private laboratories, equipment, and personnel);
- industry support and service activities (University Technology Assistance Program, Montana Entrepreneurship Center, Small Business Development Center, assistance with Small Business Innovation Research proposals, etc.; and
- interstate and regional networking (e.g., Tribal Colleges, NEWTEC, etc.).

OPPORTUNITY: Build the physical infrastructure for networking.—As of June 1990, only 40 percent of Montana had been upgraded from mechanical to digital switching. State regulatory officials should require all telephone service providers to complete the installation of digital switching as soon as possible, and to begin the installation of fiber optics in order to support expanded telecommunications capabilities in the State. Local initiatives such as now exist in southeast Montana should also be encouraged.

OPPORTUNITY: Develop a Montana high tech business council.—Advanced technology enterprises in Montana have discussed the possibility of forming an association to address common problems and to represent the industry on issues of mutual concern (insurance, worker's compensation, targeted vo-tech training, university relations, taxes, etc.). This tactic has been productive in other States and should be encouraged in Montana.

OPPORTUNITY: Legitimize professional and institutional service to industry by Montana universities.—Institutional and professional service to business and industry should be seen as a legitimate and necessary function, coequal in university policy with teaching and research. Universities must have both (1) incentives for service and (2) structures to promote service. In addition to publications, for example, decisions about faculty promotion and tenure also should reflect both patents and technical service to industry. Particularly important, based on the experience of other States, are (1) facilitating faculty and student assistance to industry; and (2) the ability to conduct proprietary R&D with university facilities and equipment on reasonable terms, including deferred compensation to the university when appropriate. Universities should allow faculty to exploit the results of R&D through private industry, including both participation and ownership interest in commercial ventures. Awareness of these matters should be cultivated among legislators, as well as members of the university community.

The Montana Entrepreneurship Center links entrepreneurs to resources, information, and expertise found in the Montana University System.

OPPORTUNITY: Invigorate and coordinate technology development, transfer, and deployment.—Montana should provide a coherent and integrated range of services for startups and existing companies, many of which need access to "medium tech" rather than cutting-edge research. This means improving the content and delivery of activities in support of technological entrepreneurship and technology-based enterprises, including activities at the State, local, and university levels, which—taken collectively—should be seen as incubators with and without walls. Elements of this set of activities include the following:

- technology resource identification ("technology ferrets" to dig out the innovations that are occurring);
- intellectual property security (a statewide policy review and reevaluation is needed);
- technology evaluation and technical assistance, focused not only on (1) venture formation/development and entrepreneurship (e.g., Montana Entrepreneurship Center) and (2) industrial extension for existing firms (e.g., Northern Montana College programs and University Technology Assistance Program), but also on (3)

An opportunity exists to legitimize professional service to industry by Montana universities.

MIKE RADEL PHOTOGRAPHY

Montana should provide a coherent and integrated range of services for startups and existing companies, many of which need access to "medium tech" rather than cutting-edge research.

Manufacturing facility of JBM Inc.

R&D grantsmanship (e.g., Small Business Innovation Research support at preproposal, bridge, and Phase III);

- positive assistance to industry in gaining access to the facilities, equipment, and talent in Federal laboratories and in Montana's colleges and universities;
- management assistance (MEC and the Small Business Development Center); and
- assistance to intrapreneurs for university-based venture development.

OPPORTUNITY: Develop revenue streams.—Money is required to support all of these "developmental" efforts. However, these funds should be seen as investments, not expenditures. Focused activities to exploit these opportunities might include the following:

- Encourage faculty intrapreneurship with regard to out-of-state and private funding sources, especially in relation to Montana's social and economic priorities.
- Leverage outside dollars (Federal and private) through such programs as EPSCOR, SBIR, etc., that involve State matching funds for cooperative projects. The recent expansion of EPSCOR to other Federal agencies, by itself, will make available an additional $30 million per year, nationwide, for cooperative infrastructure-building projects.
- Develop a mechanism and formula for investing acceptable portions of Montana funds—private and public, including the Coal Trust—in research and in private ventures that conserve or expand the Montana economy (i.e., normal venture standards with a slight rate-of-return allowance for contribution to technology base and economic development). The investment industry at large is moving away from debt and toward equity; it may therefore be time to reexamine the policies of the State Investment Board with regard to the Coal Trust and other public monies.
- Establish a strong, focused development program for all of Montana's universities—including specific programs, facilities, and equipment to be supported—and then undertake a major, five-year fund-raising campaign, targeted on private-sector giving on a nationwide and international scale. Components should include endowed chairs and research seed money, as well as new and updated, general and special purpose facilities and equipment. Total targets should be on the order of at least $250 million for science and technology capacity, including the training of elementary and secondary science, math, and technology teachers, as well as "direct" university science and technology needs. This amount is consistent with similar development drives elsewhere in the Nation.

This fund-raising drive should be coordinated with efforts to raise capital resources for the other needs of the State's universities, but must not be subordinated to them. The concept of a unitary drive for all of the needs of all of the universities is essential if the current destructive in-fighting among them is to be brought back within the bounds of constructive competition for excellence.

• Develop a targeted program to attract known technology-venture "angels" to acquire second homes in Montana and to invest in Montana-based startups (at least one such angel is known to be residing in the Flathead Valley and investing in Montana ventures). This might be done by redirecting the Montana Department of Commerce's industry recruitment efforts and linking them with the Montana Ambassadors' "Catch and Release" program. The same sort of thing could be done for potential early retirees and former Montanans now living and working elsewhere whose professional skills would be useful to the State.

OPPORTUNITY: Institutionalize science and technology policy and control.—Establish the Montana Science and Technology Advisory Council (MSTAC) as a continuing policy arm of the State within the Executive Office of the Governor. The staff of the Montana Science and Technology Alliance would be transferred out of the Department of Commerce and into the Executive Office of the Governor, where they would service both MSTAC and the Montana Science and Technology Development Board (MSTDB). The present MSTDB would remain and function as presently constituted. With reference to the present proposed Plan, MSTAC would have six specific responsibilities:

1. Appoint focus groups, after consultation with the Governor and Legislature.
2. Hire and manage the fundraiser for the science and technology capital fund drive.
3. Give continuing advice and counsel to the Governor, the Legislature, and other State agencies involved in science and technology.
4. Produce or update the Science and Technology Plan biennially.
5. Provide advice and counsel to MSTDB on specific applications for research and development project loans as they relate to the Montana Science and Technology Plan.
6. Oversee the implementation of all elements of the Montana Science and Technology Policy and Plan.

Summary

All of these challenges and opportunities can be addressed through actions that require little change in the structure of Montana's governmental, scholastic, and industrial sectors. Effective action will require that these sectors work together in new ways, with the belief that "win-win" strategies are possible. If Montanans rise to these opportunities, the State will enter the twenty-first century on a solid economic, intellectual, and social footing.

Appendix A

Bibliography

I. THE NEW TECHNOLOGICAL ECONOMY

Abelson, Philip H. "The Lost U.S. Excellence in Manufacturing" (editorial). *Science,* Vol. 248, No. 4952, 13 April 1990, p. 125.

Abetti, Pier A., Christopher W. LeMaistre, and Raymond W. Smilor, eds. *Industrial Innovation, Productivity, and Employment.* IC2 Institute, University of Texas, Austin, TX, 1987.

"The Competitiveness Question." *Perspectives* (The Conference Board, New York, NY), No. 5, 1987.

"Computers, Telephones, Tunnels." *The Economist,* 15 December 1990, p. 18.

Crawford, Jack. "Drivers of the New Economy." *Points West* (Center for the New West), Vol. 2, No. 1, Winter 1990, pp. 3-4.

Drucker, Peter. "The Futures That Have Already Happened." *The Economist,* 21 October 1989, pp. 19-24.

"Factory of the Future." *The Economist,* 30 May 1987, pp. 5-18.

Human Resources. Council on Competitiveness, Washington, DC, 1990.

"The Incredible Shrinking Company." *The Economist,* 15 December 1990, pp. 65-66.

Jaikumar, Ramchandran. "Postindustrial Manufacturing." *Harvard Business Review,* November-December 1986, pp. 69-76.

McGuire, E. Patrick. *Research and Development: Key to Competitiveness.* The Conference Board, New York, NY, n.d.

Merrifield, D. Bruce. *Issues Involved in a Growth Economy and in Industrial Competitiveness.* U.S. Department of Commerce, Washington, DC, 1988.

Naisbitt, John, and Patricia Aburdene. *Reinventing the Corporation.* Warner Books, New York, 1985.

Office of Technology Assessment, U.S. Congress. *Intellectual Property Rights in an Age of Electronics and Information.* OTA-CIT-303. U.S. Government Printing Office, Washington, DC, 1986.

Panel on Advanced Technology Competition and the Industrialized Allies. *International Competition in Advanced Technology: Decisions for America.* Office of International Affairs, National Research Council, Washington, DC, 1983.

Pollan, Stephen M., and Mark Levine. "The Secrets to Surviving the '90s and Flourishing in the 21st Century: A Guide for Small (and Large) Businesses." *U.S. News and World Report,* Vol. 109. No. 17, 29 October 1990, special advertising section.

Reich, Robert B. "The Real Economy." *Atlantic,* February 1991, pp. 35-52.

Reilly, Lucy. "Key Technologies Part II: Government Lends a Hand." *Washington Technology,* 22 November 1990, pp. 18ff.

————. "Materials Head Master List." *Washington Technology,* 21 March 1991, pp. 1, 4.

"Research and Development." *Economic Road Maps* (The Conference Board, New York, NY), Nos. 2007-2008, October 1986, pp. 1-4.

II. MONTANA'S MATERIAL RESOURCES

A. Mineral and Energy Resources

Anez, Bob. "Utility Unveils Ambitious Investment Plan." *Great Falls Tribune,* 12 March 1991, p. 1A.

Annual Report 1989. Montana Power Company, Butte, MT, 1990.

"BN Pumps Cash into Coal Traffic." *Missoulian,* 10 March 1991, p. F-2.

Brooks, Tad. "Ecological Time Bomb." *Bozeman Chronicle,* 10 February 1991, pp. 1, 8.

Brower, John C. *The Economic Impact of Coal Mining in Montana.* Bureau of Business and Economic Research, University of Montana, Missoula, MT, 1985.

Copeland, Michael D. "The New Resource Economics." In *The Yellowstone Primer: Land and Resource Management in the Greater Yellowstone Ecosystem* (ed. John A. Baden and Donald Leal), Pacific Research Institute for Public Policy, San Francisco, CA, 1990, pp. 13-23.

Gregor, Harry P. "Ethanol May be the Fuel of the Future." *Washington Post,* n.d.

Lacombe, James E. "Clean-Coal Burning Process Offers Jobs, Other Benefits to Montana, Expert Says." *Great Falls Tribune,* 10 March 1991, p. 3B.

Lynd, Lee R., et al. "Fuel Ethanol from Cellulosic Biomass." *Science,* Vol. 251, 15 March 1991, pp. 1318-1323.

McCulloch, Robin B. *Mining and Mineral Developments in Montana 1990.* Montana Bureau of Mines and Geology, Helena, MT, 1990.

————. "The Mining and Mineral Exploration Industry in Montana." Presented at 16th Annual Economic Outlook Seminar, Helena, MT, January 1991.

Montana Energy Tax Benefits. Montana Department of Natural Resources and Conservation, Helena, MT, 1989.

Montana Oil and Gas Annual Review 1989. Montana Department of Natural Resources and Conservation, Helena, MT, 1990.

Montana Oil and Gas Statistical Bulletin (Board of Oil and Gas Conservation), various issues.

Montana's Energy Resources, 4 vols. Montana Department of Natural Resources, Helena, MT, 1984.

Stroup, Richard L. *Application of Market Based Incentives to the Nonfuel Minerals Industry: A Property Rights Perspective.* Working Paper 90-23. Political Economy Research Center, Bozeman, MT, 1990.

————. "Privatizing 'Orphan' Hazardous Waste Sites: A Way to Improve Superfund." *PERC Viewpoints* (Political Economy Research Center), No. 9, April 1990.

Swanson, Larry D. "Montana's Natural Resource Industries: Past and Emerging Trends in the State's Economic Base." *Montana Business Quarterly,* Vol. 28, No. 1, Spring 1990, pp. 19-30.

————. "Montana's Natural Resource Industries: Recent Trends During an Improving Economy." In *Outlook: 1991 Economic Outlook Seminar,* Bureau of Business and Economic Research, University of Montana, Missoula, MT, 1991, pp. 18-23.

B. Agriculture and Forestry

"Ag Conference to Explore New Crops." *Billings Gazette,* 10 February 1991, n.p.

Blustein, Paul. "Scrapping Trade Barriers to U.S. Beef." *Washington Post,* 31 March 1991, pp. H1, H12.

Gilles, T.J. "Farm Forum Speaker Suggests Ways to Increase Exports." *Great Falls Tribune,* 10 February 1991, p. 2G.

Gransbery, Jim. "Wool Outlook Dismal" and "Supply to Keep Cattle Prices Strong." *Billings Gazette,* 10 February 1991, p. 1-D.

Jones, Sherry. "MSU Researchers Working on Super-Duper Tubers." *Great Falls Tribune,* 10 March 1991, p. 1G.

"Meatpacking Study Proposed." *Bozeman Chronicle,* 10 February 1991, n.p.

McMillon, Scott. "Wild About the Wapiti" and "Part of Local Herd to be Killed for Tuberculosis Test." *Bozeman Chronicle,* 10 February 1991, pp. 1, 3.

"Montola State's Newest Alternative Crop." *Great Falls Tribune,* 10 March 1991, p. 3H.

Pollack, Andrew. "Lumbering in the Age of the Baby Tree." *New York Times,* 24 February 1991, pp. F1, F6.
Schwennesen, Don. "Flathead Folks Are Intrigued by New Crops." *Missoulian,* 10 March 1991, p. F-1.

C. Biotechnology

Biotechnology Information Center, North Carolina Biotechnology Center. *State-by-State Biotechnology Directory: Centers, Companies, and Contacts.* Bureau of National Affairs, Washington, DC, 1990.
Blakely, Edward J., and Kelvin W. Willoughby. "Transfer or Generation? Biotechnology and Local-Industry Development." *Journal of Technology Transfer,* Vol. 15, No. 4, Fall 1990, pp. 31-38.
Durand, Michele. "France's Pharmaceuticals Industry: World-Class Labs Banking on Innovation." *French Advances in Science and Technology* (Embassy of France), Vol. 4, No. 3, Autumn 1990, pp. 4-5.
Eider, Robin. "State Associations Promote Biotech Growth." *The Scientist,* Vol. 5, No. 3, 4 February 1991, pp. 1, 3.
Montana's Biotech Connection. Missoula Economic Development Corporation and Montana Power Company, Missoula, MT, 1990.
Schrage, Michael. "The Biotechnology Drug 'Revolution' Is Still to Come." *Washington Post,* 1 February 1991, p. F3.

D. Environmental Resources

Caring for Our Nation's Waters. U.S. Corps of Engineers Omaha District, Omaha, NE, n.d.
Cunningham, Al. *Developing Hydropower in Montana: A Guide to Permitting and Licensing,* rev. ed. Montana Joint Water Resources Research Center, Montana State University, Bozeman, MT, 1984.
Darrow, George F., et al. *Crown of the Continent Project: A New Approach for Integrated Research, Education, and Interpretation of Ecological and Human Relations within the Crown of the Continent Ecosystem in Montana, British Columbia and Alberta.* N.p., n.c., 1990.
"Institute Proposes Environmental Taxes." *Bozeman Chronicle,* 10 February 1991, n.p.
McRae, Kevin. "Industrialist Praises State Beauty." *Billings Gazette,* 10 February 1991, p. 6-D.
"Montana's Wildlife Highway." *Sunset,* Vol. 186, No. 4, April 1991, pp. 82-85.

III. MONTANA'S HUMAN RESOURCES

A. K-12 Science and Mathematics

Czujko, Roman, and David Bernstein. *Who Takes Science? A Report on Student Coursework in High School Science and Mathematics.* American Institute of Physics, New York, NY, 1989.
Directory of Awards FY 1987-88. Directorate for Science and Engineering Education, National Science Foundation, Washington, DC, 1989.
"Education: Investment and Performance Indicators." *Points West* (Center for the New West), Vol. 2, No.1, Winter 1990, pp. 18-19.
How to Form and Operate a Local Alliance. Triangle Coalition for Science and Technology Education, Washington, DC, 1986.
Industrial Initiatives in Precollege Science Education (Proc., ACS Corporation Associates Annual Symposium, Boston, MA, 1990). American Chemical Society, Washington, DC, 1990.
Kleinhuizen, Jeff. "Sprawling Montana Is an Academic Success Story." *USA Today,* 26 February 1991, p. 4D.
Montana School Accreditation Standards and Procedures Manual. Office of Public Instruction, Helena, MT, 1989.
A Plan for Action. Triangle Coalition for Science and Technology Education, Washington, DC, 1989.
The Present Opportunity in Education. Triangle Coalition for Science and Technology Education, Washington, DC, 1988.
Professional Standards for Teaching Mathematics: Working Draft. National Council of Teachers of Mathematics, Reston, VA, 1989.
Results in Education: 1990. National Governors' Association, Washington, DC, 1990.
Time for Results: The Governors' 1991 Report on Education. National Governors' Association, Washington, DC, 1991.
Tool Kit for Science Curriculum Development. Office of Public Instruction, Helena, MT, n.d.

B. Occupationally Targeted Technical Education

Cane, Michael, et al. *Identifying and Describing the Skills Required by Work.* Employment and Training Administration, U.S. Department of Labor, Washington, DC, 1990.
Caulder, Trisha C., Joan L. Boehm, and Elizabeth G. Rabon. *What Works: Guidelines for Workplace Skills Enhancement Programs.* South Carolina Department of Education, Columbia, SC, n.d.
Education for Careers in Electronics Technology. DeVry Inc., Evanston, IL, 1989.
Featherstone, Harry E. "Educating Workers Pays Off." *NAM's Small Manufacturer,* Vol. 8, No. 5, November 1990, pp. 1-2.
Land, Tom. "Technical Training for Competitive Advantage." *Technical & Skill Training News* (American Society for Training and Development), Winter 1991, pp. 1-2, 6.
Montana Public Postsecondary Vocational-Technical Education 1989-1990. Center for Vocational Education Research Curriculum and Personnel Development, Havre, MT, 1989.
St. John, Michael, et al. *Career Development for Undereducated Adults in ABE Programs.* Portland Community College and Northwest Regional Educational Laboratory, Portland, OR, 1989.
"Tech Sharing." *Inc.,* January 1991, p. 23.
Technology-Based Education for Business Careers. DeVry Inc., Evanston, IL, 1988.
Workforce 2000: Work and Workers for the 21st Century. U.S. Department of Labor, Washington, DC, 1987.

C. Women and Minorities

American Indian Research Opportunities. AIRO Program, Bozeman, MT, n.d.
"Colleges for Tribes Gain Funds." *Billings Gazette,* 10 February 1991, n.p.
Downey, Mark. "They're Expanding Their Career Horizons." *Great Falls Tribune,* 10 March 1991, p. 1B.

D. Higher Education

"America's Best Colleges." *U.S. News and World Report,* 26 October 1987, n.p.
Crossroads: Montana Higher Education in the Nineties. Montana Education Commission for the Nineties and Beyond, Helena, MT, 1990.
Summary of the 1989 Graduate Survey. Placement Office, Montana Tech, Butte, MT, 1990.
Wallwork, Susan Selig. "Higher Education in Montana: Public Perceptions and Preferences." *Montana Business Quarterly,* Vol. 28, No. 4, Winter 1990, pp. 13-17.

E. Educational Telecommunications

Andrews, Edmund L. "'Baby Bells' Wait; Hope Judge Relents." *New York Times,* 10 March 1991, p. F5.
Barinaga, Marcia. "Science Television: Colleagues on Cable." *Science,* Vol. 251, 15 March 1991, p. 1307.
Beattie, Bruce R., and Douglas J. Young. *Montana Taxation and Expenditures: Issues and Options.* Burton K. Wheeler Center, Montana State University, Bozeman, MT, 1988.
Catalog of Computer-Based and Video Distance Learning Programs. Office of Public Instruction, Helena, MT, 1990.
Holznagel, Donald C. *A Depiction of Distance Education in the Northwest Region.* Northwest Regional Educational Laboratory, Portland, OR, 1990.

Jenks, Andrew. "Information Infrastructure Tops Hill's Science Agenda." *Washington Technology*, 21 March 1991, pp. 1, 8.

Lambda Communications Inc. *Final Report for the Montana Educational Telecommunications Project.* Montana Department of Administration, Helena, MT, 1990.

Spayd, Liz. "U-Md. Program Makes a College Degree Possible Via Cable TV." *Washington Post*, 5 March 1991, pp. C1, C5.

Stergionis, Marc. "Montanans Optimistic Over Fiber Optics" and "Burns' Proposal Aims to Spur U.S. Development of Technology." *Great Falls Tribune*, 10 March 1991, p. 1H.

Sullivan, Jerry R. *Goals and Recommendations for the Use of Telecommunications in Montana.* Montana Telecommunications Project, Helena, MT, 1989.

F. Technology-Based Industry and Entrepreneurship

Bozeman: Montana's Technology Center. Gallatin Development Corporation and Montana Power Company, Bozeman, MT, 1990.

Directory to Montana-Made Consumer Products. Montana Department of Commerce, Helena, MT, 1991.

Finegan, Jay. "Grown in Montana." *Inc.*, January 1991, pp. 62-69.

Montana: A Proposal for U.S. West Advanced Technologies. Montana Department of Commerce, Helena, MT, n.d.

Montana Business Birth-Death Study. Research and Analysis Bureau, Montana Department of Labor and Industry, Helena, MT, n.d.

Montana Business Directory. American Directory Publishing Co., Omaha, NE, 1991.

Montana Manufacturers and Product Directory. Montana Department of Commerce, Helena, MT, n.d.

Montana: On the Cutting Edge of Technology! Montana Power Company, Butte, MT, 1991.

MSE: Technologies for the Future, Responsible Resolutions for Today. MSE, Inc., Butte, MT, n.d.

News (Montana Technology Companies, Inc.), Vol. 1 No. 1, May 1990.

The 1990 Development Report Card for the States. Corporation for Enterprise Development, Washington, DC, 1990.

Rocky Mountain High Technology Directory. Leading Edge Communications, Inc., Aurora, CO, 1990.

"Success Story." *Income Plus*, November 1990, p. 37.

Swanson, Larry D. "High Tech Industry in Montana." *Montana Business Quarterly*, Vol. 28, No. 4, Winter 1990, pp. 2-8.

Vobejda, Barbara. "For the New Retirees, Out-of-the-Way Places." *Washington Post*, 27 February 1991, p. A3.

G. Workforce Trends

Montana Annual Planning Information for 1990-1991. Montana Department of Labor and Industry, Helena, MT, 1990.

Montana Employment and Labor Force Trends (Research and Analysis Bureau, Montana Department of Labor and Industry), Vol. 20, No. 3, 1990.

Montana Employment and Wages, First Quarter 1990. Research and Analysis Bureau, Montana Department of Labor and Industry, Helena, MT, 1990.

Montana Industry and Occupational Employment Outlook 1986-1995. Research and Analysis Bureau, Montana Department of Labor and Industry, Helena, MT, 1988.

Montana Supply/Demand Executive Summary, 7th ed. Montana State Occupational Information Coordinating Committee, Montana Department of Labor and Industry, Helena, MT, 1990.

Montana's Growing and Declining Industries and Occupations 1986-1995. Montana Department of Labor and Industry, Helena, MT, 1989.

Workforce to the Year 2000: Opportunities and Challenges. Montana Department of Labor and Industry, Helena, MT, 1988.

III. MONTANA'S INSTITUTIONAL RESOURCES

A. Entrepreneurship Support

Allen, David N. *Small Business Incubators and Enterprise Development.* Institute of Public Administration, Pennsylvania State University, University Park, PA, 1985.

Campbell, Candace. "Change Agents in the New Economy: The Role of Business Incubators in Job Creation and Economic Development." Presented at 1st National Business Incubation Association Conference, Philadelphia, PA, 1987.

Investing in Entrepreneurial Enterprise: Building a Base of New Companies and Products in Indiana. Indiana Corporation for Science and Technology, Indianapolis, IN, n.d.

B. Research Infrastructure

MONTS III/EPSCOR Advanced Development Program in Montana. Proposal submitted to the National Science Foundation. Montana State University, Bozeman, MT, 1990.

Northern Rockies Environmental and Waste Technology Educational Consortium (NEWTEC). Preproposal submitted to the U.S. Department of Energy-Idaho. Montana College of Mineral Science and Technology, Butte, MT, 1990.

Richards, Evelyn. "Data Network Funding May Be First Step Toward U.S. 'Technology Policy.'" *Washington Post*, 31 January 1991, pp. E1, E4.

Suplee, Curt. "Gravity's Unearthly Pull." *Washington Post*, 17 March 1991, p. D3.

C. University-Industry Linkages

Advanced Minerals and Hazardous Waste Processing Center of Excellence: Organizational Description and Progress Report. Montana College of Mineral Science and Technology, Butte, MT, 1990.

Center for Interfacial Microbial Process Engineering: Center Overview. Montana State University, Bozeman, MT, 1990.

Hullar, Theodore L. "Wanted: Enterprising Scientists to Launch New Businesses." *The Scientist*, Vol. 5, No.3, 4 February 1991, pp. 13, 15.

Salkind, Michael J. "Promoting University-Industry Ties: A Proposed Action Plan from the ASME Council on Education." *Mechanical Engineering*, December 1987, pp. 66-67.

Schoenecker, Timothy S., Donald D. Myers, and Peter Schmidt. "Technology Transfer at Land-Grant Universities." *Journal of Technology Transfer*, Vol. 14, No. 2, Spring 1989, pp. 28-32.

Vision: Research and Creative Activities. University of Montana, Missoula, MT, 1989.

D. Technology Transfer and Industrial Extension

Clarke, Marianne K., and Eric N. Dobson. *Promoting Technological Excellence: The Role of State and Federal Extension Activities.* National Governors' Association, Washington, DC, 1989.

Roessner, J. David, and Alden S. Bean. "Industry Interactions with Federal Laboratories." *Journal of Technology Transfer*, Vol. 15, No. 4, Fall 1990, pp. 5-14.

Working Together for Rural America: A Strategic Plan for the 1990s. Forest Service, U.S. Department of Agriculture, Washington, DC, 1990.

E. Federal Laboratories in Montana

Babbitt, Ronald E. *Improved Streamflow and Water Quality Monitoring Using a Microprocessor-Based System.* Research Note INT-377. Forest Service Intermountain Research Station, U.S. Department of Agriculture, Ogden, UT, 1987.

The Edge of Discovery: The National Institute of Allergy and Infectious Diseases. NIH Publication No. 88-2773. U.S. Department of Health and Human Services, Washington, DC, 1988.

Fish Technology Center, Bozeman, Montana. Fish and Wildlife Service, U.S. Department of Interior, n.c., n.d.

Forest Sciences Laboratory. Forest Service Intermountain Research Station, U.S. Department of Agriculture, Ogden, UT, 1980.

Intermountain Fire Services Laboratory. Forest Service Intermountain Research Station, U.S. Department of Agriculture, Ogden, UT, 1986.

Sandberg, D.V., and Janice Peterson. "A Source Strength Model for Prescribed Fires in Coniferous Logging Slash." Presented at 21st Annual Meeting of the Air Pollution Control Association, Pacific Northwest International Section, Portland, OR, 1984.

Ward, Darold E. "Air Toxics and Fireline Exposure." Presented at 10th Conference on Fire and Forest Meteorology, Ottawa, Canada, 1989.

———. "Emissions from Prescribed Burning of Chaparral." Presented at the Annual Meeting of the Air and Waste Management Association, Anaheim, CA, 1989.

Ward, Darold E., and Colin C. Hardy. "Advances in the Characterization and Control of Emissions from Prescribed Fires." Presented at 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA, 1984.

Ward, Darold E., et al., eds. *The Effects of Forest Fire Smoke on Firefighters: A Comprehensive Study Plan.* Report INT-4404. Forest Service Intermountain Fire Sciences Laboratory, U.S. Department of Agriculture, Missoula, MT, 1989.

F. Local Initiatives

The Practice of Local Government Planning. N.p., n.c., n.d.

Taking Charge: How Communities Are Planning Their Futures. International City Management Association, Washington, DC, n.d.

IV. MONTANA'S CHALLENGES AND OPPORTUNITIES

A. Higher Education

"Healthy University System is Vital to Montana's Future" (editorial). *Great Falls Tribune,* 10 February 1991, p. 8A.

Marshall, Jonathan H. "State's Congressional Delegation Goes to Work." *Great Falls Tribune,* 10 February 1991, p. 5C.

B. Finance

Biennial Report, 1986-88. Montana Department of Revenue, Helena, MT, n.d.

"The Needs of Montana's Rural Banks." *Policy Forum* (Center for Population Research, University of Montana), January 1990, p. 1.

Petruno, Tom. "Worried Americans are Stashing the Cash." *Bozeman Chronicle,* 10 February 1991, p. 19.

Stergionis, Marc. "Montana's Banks Record Solid Profits." *Great Falls Tribune,* 10 February 1991, n.p.

Tax Expenditure Report for the State of Montana, FY 1992-1993. Montana Department of Revenue, Helena, MT, 1991.

C. Strategic Plans

Atkinson, Robert D. "Ten Lessons for Successful State Technology Policy-Making." *Commentary* (National Council for Economic Development), Vol. 13, No. 2, Summer 1990, pp. 20-28.

Brockman, Paul R., and Paul B. Phelps. *State-Funded Seed Capital Programs Available for New-Technology-Based Ventures.* LFW Management Associates, Alexandria, VA, 1989.

Government-University-Industry Research Roundtable and National Governors' Association. *State Government Strategies for Self-Assessment of Science and Technology Programs for Economic Development.* National Academy Press, Washington, DC, 1987.

Governor's Conference on Science and Engineering Education, Research, and Development. *Toward a Prosperous Future: A Strategic Plan for Maintaining New York State's Scientific and Technological Competitiveness in the 21st Century.* New York State Science and Technology Foundation, Albany, NY, 1990.

Indicators of Economic Capacity. AmeriTrust and SRI International, Cleveland, OH, 1986.

Integrated Statewide Plan for Technology-Based Economic Development. New Mexico Science and Technology Commercialization Commission, 1989.

Jones, Megan. "Helping States Help Themselves." *Issues in Science and Technology,* Vol. 6, No. 1, Fall 1989, pp. 56-60.

Lipman, Barbara J. *State and Local Initiatives on Productivity, Technology, and Innovation: Enhancing a National Resource for International Competitiveness.* Report A-114. Advisory Commission on Intergovernmental Relations, Washington, DC, 1990.

New Directions: Building an Economic Future for Montana's Children. Corporation for Enterprise Development, Washington, DC, 1990.

Osborne, David. "Refining State Technology Programs." *Issues in Science and Technology,* Vol. 6, No. 4, Summer 1990, pp. 55-61.

Partnership for Progress: An Economic Development Proposal of the Montana Ambassadors. Montana Ambassadors, Helena, MT, 1988.

Phelps, Paul B. *Centers of Excellence: A Catalogue.* LFW Management Associates, Alexandria, VA, 1988.

State Technology Programs in the United States 1988. Office of Science and Technology, Minnesota Department of Trade and Economic Development, St. Paul, MN, 1988.

State Technology Strategy. Indiana Corporation for Science and Technology, Indianapolis, IN, 1989.

Strategic Plan for Investments in Technology Development. Ben Franklin Technology Center of Southeastern Pennsylvania, Philadelphia, PA, 1990.

Tanski, Patricia. "The Special Needs of Small States." *Issues in Science and Technology,* Vol. 6, No. 1, Fall 1989, pp. 61-65.

van der Werff, Terry J. *Science and Technology Advice to State Governors.* School of Science and Engineering, Seattle University, Seattle, WA, 1989.

Wheeler, Gerry, ed. *Science, Technology, and Economic Development: A Compilation of Student Papers from Physics 321, "Our Technological Society."* Department of Physics, Montana State University, Bozeman, MT, 1991.

Appendix B

Executive Order 13-90

STATE OF MONTANA
OFFICE OF THE GOVERNOR
EXECUTIVE ORDER NO. 13-90
EXECUTIVE ORDER CREATING THE MONTANA SCIENCE AND TECHNOLOGY ADVISORY COUNCIL

WHEREAS, it is the policy and goal of the State of Montana under Title 90, Chapter 3, MCA, "to encourage scientific and technological development within the state in order to keep pace with a changing economic structure and to create new jobs and expand business opportunities"; and

WHEREAS, scientific research is a major component of a state's economic development strategy; and

WHEREAS, the development of new technology and its application has been viewed as critical to the long-range economic and social future of the state and nation; and

WHEREAS, the Montana Board of Science and Technology Development ("Board") has been successful in creating a partnership among the private sector, the university community and state government, to assist in the advancement of scientific and technological development in the state; and

WHEREAS, the creation and development of a state science and technology plan would identify basic research capabilities in the state, assist in the development of a research agenda; strengthen Montana's efforts in applied science and technology; and further serve to develop the partnership among the private sector, university community and government;

NOW, THEREFORE, I, STAN STEPHENS, Governor of the State of Montana, by virtue of the authority vested in me by the Constitution and laws of the State of Montana, and specifically section 2-15-122, MCA, do hereby create the Montana Science and Technology Advisory Council.

I. PURPOSE

The Council shall:

1. Develop and recommend a state science and technology plan to the Governor, after review and approval by the Board. The state science and technology plan must be submitted to the Board by no later than May 1, 1991. The state science and technology plan must include, but not be limited to the following:

(a) A science and technology development policy;

(b) An identification of the strengths and weaknesses in the basic science resources and research capabilities in the state;

(c) A "research agenda" designating areas for potential scientific and technological development;

(d) A plan to encourage basic science research and strengthen Montana's efforts in applied science;

(e) Recommendations on how to strengthen the partnership between the private sector, university community and government, for science and technological development and financing;

(f) Recommendations on how to improve and sustain the infrastructure for research and research training; and

(g) Recommendations on how to achieve research excellence.

2. Review and comment to the Board on specific applications for research and development project loans as relates to the adopted Montana Science and Technology Plan.

II. COMPOSITION

The Council shall consist of eleven members. The names and addresses of the members who shall serve at the pleasure of the Governor are:

John Brower — 1 year
MSTA Board Member
384 Little Basin Creek Road
Butte, MT 59701

Walter Hill — 2 years
Professor of Biochemistry
Director of Center of Excellence in Biotechnology
University of Montana
Missoula, MT 59812

Robert E. Ivy — 2 years
President, CEO and Chairman
Ribi ImmunoChem Research, Inc.
P.O. Box 1409
Hamilton, MT 59840

Richard K. Quisenberry — 1 year
Vice President & Research Director
The Dupont Company
Experimental Station – 328/411
Wilmington, DE 19889-0328

Carl E. Russell — 2 years
Executive Director
Montana Science & Technology Alliance
46 N. Last Chance Gulch, Suite 2B
Helena, MT 59620

Clarence Speer — 2 years
Professor and Head of Veterinary Microbiology
Montana State University
Bozeman, MT 59715

David Toppen — 2 years
Deputy Commissioner for Academic Affairs
The Montana University System
33 South Last Chance Gulch
Helena, MT 59620

Larry Twidwell — 1 year
Professor of Metallurgical Engineering
Montana College of Mineral Science and Technology
Butte, MT 59701

Gerry Wheeler — 1 year
Professor of Physics
Montana State University
Bozeman, MT 59715

Dr. William R. Wiley — 1 year
Senior Vice President
Battelle Memorial Institute and Director of the Department of Energy
Pacific Northwest Laboratories
P.O. Box 999
Richland, WA 99351

Bud Wonsiewicz — 2 years
Vice President-Science and Technology
U.S. West Advanced Technology Group
6200 S. Quebec Street, #430
Englewood, CO 80111

Robert E. Ivy shall serve as Chairperson.

A majority of the membership of the Council constitutes a quorum to do business.

III. COMPENSATION

Council members eligible for compensation under 2-15-122(5) shall be compensated by the Department of Commerce at the rate of $25.00 for each day actually and necessarily engaged in the performance of Council duties. All members shall be reimbursed for travel expenses pursuant to section 2-15-122(5).

IV. DURATION

As required by section 2-15-122, MCA, the Science and Technology Advisory Council shall exist for a period of two years from the effective date of this order, unless extended by Executive Order.

EFFECTIVE DATE

This order is effective immediately.

GIVEN under my hand and the GREAT SEAL of the State of Montana, this 22nd day of October, in the year of our Lord, one thousand, nine hundred and ninety.

Stan Stephens
STAN STEPHENS, Governor

ATTEST:

Mike Cooney
MIKE COONEY, Secretary of State

Two thousand five hundred copies of this public document were published at an estimated cost of three dollars and twenty-one cents per copy, for a total of eight thousand thirty dollars, which includes five thousand one hundred eighty dollars for printing and two thousand eight hundred fifty dollars for distribution